http://pubsonline.informs.org/journal/mnsc/

MANAGEMENT SCIENCE
Vol. 64, No. 12, December 2018, pp. 5725–5747
ISSN 0025-1909 (print), ISSN 1526-5501 (online)

CEO Confidence and Unreported R&D

Ping-Sheng Koh,[a] **David M. Reeb,**[b] **Wanli Zhao**[c, d]

[a] ESSEC Business School, Singapore 139408; [b] NUS Business School, National University of Singapore, Singapore 119245; [c] College of Business, Southern Illinois University, Carbondale, Illinois 62901; [d] Hanqing Advanced Institute of Economics and Finance, Renmin University of China, Beijing 100872, China

Contact: kohp@essec.edu, http://orcid.org/0000-0001-6228-1918 (P-SK); dmreeb@nus.edu.sg, http://orcid.org/0000-0001-9983-6139 (DMR); zhaowanli@ruc.edu.cn, http://orcid.org/0000-0001-8600-4720 (WZ)

Received: July 20, 2015
Revised: January 9, 2016; July 28, 2016
Accepted: March 17, 2017
Published Online in Articles in Advance: August 31, 2017

https://doi.org/10.1287/mnsc.2017.2809

Abstract. We investigate whether managerial traits influence corporate decisions to provide mandatory financial disclosures. The results indicate that firms with confident chief executive officers (CEOs) are 24% more likely to report their research and development (R&D) expenditures relative to firms with cautious CEOs. Exploiting staggered, state-level regulatory shocks and changes in CEO type, we find substantial evidence that cautious CEO firms fail to report R&D expenditures. After a plausibly exogenous shock to managerial reporting liability, cautious CEO firms exhibit a 35% larger reduction in unreported R&D relative to confident CEO firms. Interestingly, confident CEO firms do not exhibit more innovation than their cautious CEO counterparts after taking into account their differing propensities to report corporate R&D. Overall, our analysis suggests that the precision or reliability of mandatory disclosures systematically varies with managerial characteristics.

History: Accepted by Amit Seru, finance.
Supplemental Material: The Internet appendix is available at https://doi.org/10.1287/mnsc.2017.2809.

Keywords: innovation • overconfident CEOs • missing R&D • mandatory disclosure • corporate opacity

1. Introduction

Beginning with the Securities Act of 1933, financial regulations expanded to include a wide spectrum of issues, including mandatory financial reporting and corporate governance (Simon 1989). Yet the underlying efficacy of these regulations engenders substantial debate (e.g., Inderst and Ottaviani 2012). Coffee (1984) argues that mandatory disclosure regulations facilitate market participation because they create an affirmative duty to report material corporate activities to investors. However, the determination of materiality about an activity relies on subjective, managerial discretion. The Securities and Exchange Commission (SEC) encourages managers to make qualitative assessments regarding material information to satisfy the "reasonable investor" perspective provided by the U.S. Supreme Court (Huang 2005). Corporate research and development (R&D) expenditures are an important, mandatory component of financial statements that depend on managers to evaluate materiality (Cassiman and Veugelers 2006). 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. Among the ExecuComp firms in our sample, over one-third do not provide information on their R&D spending. Koh and Reeb (2015) report that a substantial number of these missing R&D firms engage in substantive patent activity. Against this backdrop, we seek to understand the nature of the managerial decision to report or not report corporate R&D expenditures.

Managerial confidence is arguably one of the most important executive traits that influences corporate decisions (Ben-David et al. 2013).[1] Research in accounting suggests that managerial confidence affects corporate decisions to provide voluntary disclosures (Hilary and Hsu 2011). By contrast, the decision to report mandatory, financial statement data are typically treated as fixed under the assumption that reporting requirements alleviate concerns about incomplete information (Fishman and Hagerty 2003). Predicated on this notion, studies on corporate performance implicitly assume that mandatory, financial statement data do not suffer from a disclosure bias. Yet a key component in evaluating if and how managerial biases affect firm performance relies on whether managerial biases affect mandatory financial statements.

Exploiting differences in input and output measures of R&D to identify unreported R&D, we investigate whether managerial confidence systematically influences the decision to reveal R&D expenditures. Firms that fail to report R&D expenditures but engage in patent activity (unreported R&D firms) provide a distinctive setting for investigating whether managerial confidence influences the reliability of financial statement data.[2] Designing tests to determine whether a managerial bias affects a specific firm activity, such as R&D, requires an understanding of whether the

managerial bias affects the propensity to disclose the activity. For instance, Galasso and Simcoe (2011) and Hirshleifer et al. (2012) report that managerial confidence (or overconfidence) leads firms to engage in more innovation activities than their more cautious counterparts. Building on this work, we argue that managerial confidence could potentially influence the decision to report R&D expenditures.

Confident managers potentially view their R&D expenditures as generating positive outcomes and overestimate project future cash flows (Goel and Thakor 2008, Ben-David et al. 2013). Arguably, these issues increase a confident manager's inclination to disclose his or her firm's R&D spending. By contrast, cautious CEOs arguably 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 may decide 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 report R&D expenditures.

Our empirical analysis begins with an exploration of the cross-sectional relation between CEO confidence and the acknowledgment of corporate R&D expenditures. To investigate the role of financial regulations in improving the information environment, we examine the incidence or likelihood of unreported 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).

Using data from Compustat, ExecuComp, and the U.S. Patent and Trademark Office (USPTO), our main sample comprises 18,407 firm-year observations from 1992 to 2010. Over one-third (35.5%) 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%, respectively). Approximately 17.5% of the nonreporting R&D observations engage in patent activity, which we designate as unreported R&D firms. We focus on patent applications rather than patent approvals in order to limit the lag between the R&D spending input and the filing of patent applications.[3] Kortum and Lerner (2000) and Galasso and Simcoe (2011) observe that patent filings typically occur near the date of invention because of patent rules that incentivize quick filings. As such, we adopt a contemporaneous mapping between R&D reporting and patent applications to identify unreported R&D firms. However, given the length or duration of the innovation process can vary, we also use alternative time lags between R&D reporting and patent applications to identify unreported R&D firms yielding inferences similar to our main findings.

Classifying CEOs by the unexercised exercisable option moneyness metric results in roughly 45% of the CEOs classified as confident. The incidence of missing R&D expenditure data differs 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 firms that exhibits symptoms of positive R&D—namely, the unreported R&D firms.

We find lower incidences of unreported R&D in firms with confident CEOs relative to those with cautious CEOs. On the basis of the full sample (propensity-score-matched sample) of positive and unreported R&D firms, we find that confident CEOs are associated with a 24% (28%) lower likelihood of exhibiting unreported R&D relative to cautious CEOs. Considerations such as firm size, profitability, volatility, industry competition, past stock return, and compensation contract variations do not materially affect these results. To determine whether 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 nondisclosure.[4]

Next, we use an exogenous, staggered 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 secrets from employee movement to rival firms. In particular, our examination relies on state-level legislative decisions on the 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 CEOs' concerns with competitor discovery of corporate innovation should decrease with the adoption of 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. By contrast, firms changing from a confident to a cautious CEO are significantly more likely to become unreported R&D firms. Specifically, we find that changing from a confident CEO to a cautious CEO leads to a 7% *increase* in the incidence of unreported R&D. Likewise, changing from a cautious manager to a confident manager results in about a 7% *reduction* in the incidence of unreported R&D. Various difference-in-differences specifications around CEO turnover provide consistent evidence that cautious CEO firms are less likely 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, because of 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 opacity. While both types of CEOs reduce the incidence of unreported R&D after the disclosure reform, the effect is roughly 35% larger in cautious CEO firms relative to confident CEO firms. Because of the lower incidence of unreported R&D firms in the postdisclosure reform period (which is associated with a 35%–48.2% decrease in the relative disclosure bias), tests on the role of CEO confidence on innovation potentially contain less measurement error in the postdisclosure reform period.

To the extent that CEO confidence influences the disclosure of R&D expenditures, 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 postdisclosure 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 (namely, predisclosure and postdisclosure 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 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% *more* likely to report positive R&D relative to cautious CEO firms. By contrast, in the low R&D disclosure bias period, the proportion of positive R&D-reporting firms is about 7% *lower* in confident CEO firms than in cautious CEO firms. Further tests indicate that confident CEO firms exhibit approximately 15% higher reported R&D in the high R&D disclosure bias period relative to cautious CEO firms. However, in the postdisclosure reform period, we find no difference in 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 unreported R&D firms), we find no difference 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 8% *greater* than in cautious CEO firms. By contrast, this relation reverses in the low R&D disclosure bias period, where we find confident CEO firms have about a 10% *lower* likelihood of having patent activity relative to cautious CEOs. In addition to disclosure bias, we consider a potential alternative explanation for these results—namely, that confident CEOs, relative to their cautious CEO counterparts, reduce their risk-taking behavior in the low bias period. Additional tests, however, provide evidence inconsistent with this explanation. Overall, we interpret this evidence to suggest that managerial confidence influences both the disclosure and patenting of corporate R&D, and that their relations are further affected by overall financial regulatory environment.

Our results are robust to a variety of econometric specifications, including different matching procedures or the adoption of alternative lag structures in

identifying unreported firms (e.g., we identify unreported firms as those without reported R&D for the past year or past five years but apply for patents in the current year). We also consider different treatment approaches to missing R&D, including a Heckman self-selection model, inverse probability weighting, and multiple imputation. All of these approaches provide evidence that missing R&D is not simply white noise but is instead related to managerial confidence.

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 mandatory financial disclosures in overcoming corporate silence systematically varies with managerial confidence.

Second, our findings provide evidence that cautious or less confident 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 chief financial officer (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, excluding firms with missing R&D expenditure data can introduce substantial bias into the analysis.

Finally, we document that after a change in the disclosure regulatory regime, confident CEO firms appear to engage in similar or fewer innovation activities using both input and output measures of R&D. These results are in stark contrast to recent research that documents 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 influence real investment activity. Overall, our analysis suggests that the precision or reliability of mandatory financial corporate disclosures varies 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 (Standard Industrial Classification (SIC) codes between 4000 and 4099) and financial services (SIC codes between 6000 and 6799) because of their different operating and reporting environments. 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 exercisable in-the-money stock options (Malmendier and Tate 2005).[5] More specifically, we identify CEOs as confident if their in-the-money exercisable options exhibit greater than 67% 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. Unreported 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 *Unreported R&D* firms. Specifically, these are firms with missing or blank R&D expenditure data that seek patent applications each year. We measure reported R&D investment by firms' disclosed R&D expenditures divided by total assets. Furthermore, to mitigate the time lag between patents applied and R&D investment, we use the accumulated R&D stock as in Hall (1990) and Galasso and Simcoe (2011). Specifically, *R&D Stock* relies on the accumulative R&D expenditures over the past 10 years with an annual 15% amortization.

2.4. Matched Sample

To develop appropriate counterfactuals, we also employ a propensity-score matching model (without replacement using a caliper of 0.1%) to generate a matched sample between firms with confident and

cautious CEOs. We match firms within a same industry (two-digit SIC) and year combination based on their size, market-to-book, leverage, return on assets (ROA), volatility, institutional ownership, CEO age, CEO gender, CEO tenure, CEO delta, CEO vega, industry average R&D, prior stock return, and the number of patents. 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 CEO vega to filter out the variation in compensation policy between confident and cautious CEOs. Similarly, we match on past stock returns to isolate the effect of performance on disclosure choice. In addition, we control for the number of patents to ensure that the disclosure difference between confident and cautious CEOs is not because the R&D expenditure is immaterial while generating the same amount of patents (i.e., the propensity of generating patents given R&D expenditure is similar across two types of CEOs). Finally, we impose the restriction that our treatment group firms are different from the control group firms. With the exception of the CEO turnover tests, we exclude firms that experience a change in CEO type; thus we strictly match between distinct firms that have confident CEOs and those that have a cautious CEO.[6] For our main test, the matching process yields a sample of 662 firm-year observations with equal numbers of observations with confident or 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 as 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. *CEO Delta* (*CEO Vega*) measures CEO wealth change in dollars to a 1% change in stock price (annualized standard deviation of stock return). Extant research has suggested that variations in CEO delta and vega lead to different CEO risk-taking behavior (Coles et al. 2006), while Hirshleifer et al. (2012) and Ederer and Manso (2013) document that CEO delta and vega are related to firms' R&D investments. Moreover, Armstrong et al. (2013) observe that both CEO delta and vega need to be considered concurrently when examining equity incentives on financial reporting.[7]

We include annual industry competition, which is measured by a Herfindahl index based on sales for each two-digit SIC code. We control for industry competition as a managerial incentive to report R&D spending may be due to strategic consideration given industry competition. Prior firm performance may also influence CEO confidence, leading us to include it as a control variable. Finally, we include *Stock Return*, which is the buy-and-hold return for the prior three fiscal years (Hirshleifer et al. 2012).

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% of observations in the sample are classified as a confident-CEO firm. About 35.5% of our sample observations do not report their R&D expenditure. Unreported R&D firms represent about 6.2% of our overall sample and comprise about 17.5% of missing R&D firms. Average firm size is roughly $1,163 million, and average *R&D Stock* is $488 million (assume missing R&D as zeros). Firms have approximately 52% of total liabilities in their total assets. The mean (median) ROA is 13.4% (13.9%). On average, the market-to-book ratio is 3.2 and stock volatility is 12.1%. Institutional investors own about 55% of the equity. In the full sample, the average CEO age is 55 years, and only 1.8% 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% of firms' total assets. The average (log) CEO delta is 5.366, and the (log) CEO vega has a mean value of 3.645. The average number of patent applications is 23, and the Herfindahl index for industry competition has a mean (median) of 0.065 (0.044). Finally, the mean buy-and-hold stock return for the prior three years is 58.8%.

Columns (4)–(6) report the matched sample statistics between missing and positive R&D firms. Compared with the full sample, the matched sample exhibits smaller firm size and leverage, larger volatility, institutional ownership, CEO tenure, CEO delta, CEO vega, and industry-level R&D as well as industry competition, while showing roughly the same average market-to-book ratio and CEO age. Columns (7)–(9) present the summary statistics for the matched sample between unreported R&D firms and positive R&D firms. We find that the proportion of unreported R&D is lower than in the full sample while the average firm size, leverage, ROA, and stock return are also lower than those in the full sample.

In panel B, we present the univariate test results comparing firms with confident and cautious CEOs based on the two matched samples. For both matched samples, we find firms with confident CEOs no longer differ from firms with cautious CEOs across all the matching dimensions (columns (3) and (6); t-statistics < 1.60). 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. For the matched

Table 1. Summary Statistics and Univariate Test

Panel A: Summary statistics

	Full sample			Matched sample (Missing R&D)			Matched sample (Unreported R&D)		
	Mean	Median	Std. dev.	Mean	Median	Std. dev.	Mean	Median	Std. dev.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Confident	0.453	0.000	0.497	0.500	0.500	0.500	0.500	0.500	0.500
Missing R&D	0.355	0.000	0.478	0.193	0.000	0.395	0.024	0.000	0.133
Unreported R&D	0.062	0.000	0.241	0.043	0.000	0.202	0.024	0.000	0.133
Firm Size	7.059	6.899	1.536	6.613	6.527	1.542	6.415	6.263	1.546
R&D Stock	488.313	12.135	2,367.266	628.298	106.300	2,487.954	569.120	141.587	2,223.999
Leverage	0.516	0.519	0.226	0.452	0.452	0.220	0.422	0.419	0.220
ROA	0.134	0.139	0.106	0.128	0.130	0.067	0.118	0.124	0.108
Market-to-book	3.185	2.351	3.508	3.184	2.442	3.108	3.229	2.461	3.024
Volatility	0.121	0.104	0.068	0.144	0.131	0.067	0.152	0.140	0.069
Inst_own	0.547	0.616	0.310	0.622	0.691	0.280	0.630	0.689	0.267
CEO Age	55.369	55.000	7.684	55.384	55.000	7.220	55.030	55.000	7.023
CEO Gender	0.018	0.000	0.131	0.010	0.000	0.101	0.005	0.000	0.067
CEO Tenure	3.814	4.111	1.423	3.992	4.290	1.301	3.954	4.110	1.299
Industry Average R&D	0.036	0.016	0.036	0.070	0.073	0.025	0.075	0.077	0.017
CEO Delta	5.366	5.340	1.544	5.414	5.303	1.340	5.391	5.297	1.313
CEO Vega	3.645	3.778	1.660	3.777	3.893	1.535	3.768	3.870	1.473
Patent Application	23.230	0.000	132.667	31.972	2.000	162.268	33.003	5.000	175.812
Industry Competition	0.065	0.044	0.060	0.038	0.036	0.016	0.039	0.036	0.014
Stock Return	0.588	0.355	1.162	0.626	0.242	1.415	0.552	0.201	1.411
N	18,407			1,056			662		

Panel B: Univariate test

CEO type:	Matched sample for missing R&D			Matched sample for unreported R&D		
	Confident	Cautious	*t*-test	Confident	Cautious	*t*-test
	(1)	(2)	(3)	(4)	(5)	(6)
Missing R&D	0.215	0.168	1.90*	—	—	—
Unreported R&D	**0.030**	**0.057**	**2.21****	**0.018**	**0.030**	**2.05****
Firm Size	6.664	6.553	1.16	6.457	6.372	0.70
R&D Stock	641.742	612.604	0.19	648.883	487.653	0.93
Leverage	0.457	0.445	0.86	0.426	0.420	0.35
ROA	0.133	0.122	1.60	0.125	0.111	1.60
Market-to-book	3.304	3.043	1.36	3.330	3.125	0.87
Volatility	0.144	0.144	0.08	0.150	0.153	0.54
Inst_own	0.621	0.622	0.05	0.636	0.622	0.70
CEO Age	55.437	55.324	0.25	55.313	54.741	1.05
CEO Gender	0.012	0.008	0.65	0.003	0.006	0.59
CEO Tenure	4.003	3.969	0.92	4.002	3.883	1.40
Industry Average R&D	0.069	0.071	1.32	0.074	0.075	0.82
CEO Delta	5.446	5.369	1.50	5.375	5.407	0.31
CEO Vega	3.849	3.692	1.55	3.845	3.689	1.36
Patent Application	14.396	9.748	1.55	18.701	14.204	1.22
Industry Competition	0.037	0.038	1.27	0.039	0.038	0.97
Stock Return	0.668	0.577	1.04	0.578	0.527	0.46
N	528	528		331	331	

Notes. Panel A presents the mean, median, and standard deviations of firm characteristics for both full and matched samples. The propensity-score-matched sample is based 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, the number of patents, past stock returns, and within the same (two-digit SIC) industry-year combination, with no overlapping of the treatment group firms and the control group firms. Panel B shows univariate mean test results.

sample between missing and positive R&D firms (columns (1)–(3)), we observe different R&D disclosure choices between firms with confident CEOs and those with cautious CEOs: the former are less likely to be unreported R&D firms (column (3); *t*-statistics = 2.21). Similarly, for the matched sample between unreported and positive R&D firms, we find firms with cautious CEOs are more likely to be unreported R&D firms than

firms with confident CEOs (column (6); t-statistics = 2.05). 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:

$$\begin{aligned}\text{Prob}(Y) = f(&\textit{Confident}, \textit{Firm Size}, \textit{Leverage}, \textit{ROA},\\ &\textit{Market-to-book}, \textit{Volatility}, \textit{Inst\_own},\\ &\textit{CEO Delta}, \textit{CEO Vega},\\ &\textit{Industry Competition}, \textit{Stock Return},\\ &\text{Industry and year fixed effects}),\end{aligned} \quad (1)$$

Table 2. CEO Overconfidence and R&D Disclosure

	Full sample		Matched sample	
Dependent variable:	*Missing R&D*	*Unreported R&D*	*Missing R&D*	*Unreported R&D*
	(1)	(2)	(3)	(4)
Constant	−2.810***	−5.774***	−0.755	−2.250***
	(−3.70)	(−4.77)	(−0.41)	(−5.65)
Confident	**0.187***	**−0.133****	**−0.003**	**−0.215****
	(1.87)	**(−1.99)**	**(−0.09)**	**(−2.35)**
Firm Size	−0.052	0.172**	0.378*	0.768**
	(−1.03)	(2.49)	(1.90)	(2.10)
Leverage	0.757***	−0.059	0.694	0.731
	(2.85)	(−0.16)	(0.94)	(0.22)
ROA	1.829***	1.700**	3.321**	5.710***
	(3.78)	(2.08)	(2.23)	(2.88)
Market-to-book	−0.059***	−0.049***	−0.101	−0.043
	(−4.82)	(−2.90)	(−1.41)	(−0.31)
Volatility	−3.222***	−3.531***	−9.098***	−7.064*
	(−5.29)	(−2.99)	(−2.73)	(−1.90)
Inst_own	−0.218	0.163	−1.183**	1.207
	(−1.17)	(0.56)	(−2.10)	(1.28)
CEO Delta	0.018	0.070	−0.235*	−0.942***
	(0.49)	(1.13)	(−1.81)	(−2.71)
CEO Vega	−0.187***	−0.144***	−0.474***	−0.193**
	(−5.91)	(−2.76)	(−4.39)	(−2.35)
Industry Competition	−0.784	−1.573	−1.445	−2.810
	(−0.90)	(−1.16)	(−0.36)	(−1.61)
Stock Return	−0.046	−0.160***	−0.133	−0.383*
	(−1.57)	(−3.50)	(−1.17)	(−1.81)
Industry and year dummy	Yes	Yes	Yes	Yes
Observations	18,407	13,094	1,056	662
Pseudo R^2	0.336	0.246	0.413	0.542

Notes. This table presents results of the effect of CEO confidence on R&D disclosure choice. All variables are defined in the appendix. 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 * indicate significance at the 1%, 5%, and 10% levels using two-tailed tests, respectively.

where Y represents firms reporting missing R&D or an unreported R&D firm. All other variables are as defined earlier.

Columns (1) and (2) show results based on a 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, CEO confidence is positively related to missing R&D reporting in the full sample tests (z-statistics = 1.87) but insignificant in the matched sample tests ($|z$-statistics$| < 0.09$). By contrast, we find that confident CEOs are less likely to hide their R&D investment information by being in an unreported R&D firm (see columns (2) and (4); z-statistics = −1.99 and −2.35 for the full and matched sample tests, respectively). Economically, the coefficients indicate that a confident CEO firm is 24% (28%) less likely to be an unreported R&D firm in the full (matched) sample tests.[8] 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 > 2.08). On the other hand, higher market-to-book ratio and volatility are negatively associated with the likelihood of reporting missing R&D ($|z$-statistics$| > 2.90$) in the full sample but not in the matched sample. We also find that larger firms are more likely to be unreported R&D firms (z-statistics > 2.10), while more volatile firms are less likely to be unreported R&D firms ($|z$-statistics$| > 1.90$). Firms with better past stock return tend to disclose their R&D investment ($|z$-statistics$| > 1.81$). Finally, *CEO Vega* is negatively related to reporting missing R&D as well as being an unreported R&D firm ($|z$-statistics$| > 2.35$).

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 we 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 Figures 1(a) and 1(b). The first histogram in Figure 1(a) 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 (0.187) is significantly different from the mean estimated coefficients from the simulations (p-value = 1.00). Similarly, the second graph in Figure 1(b) shows that the mean estimated coefficients for *Confident* from the simulations is insignificantly different from zero for the unreported R&D test (p-value = 0.35). Further tests suggest that the estimated coefficient in Table 2 (−0.133) is significantly different from

Figure 1(a). (Color online) Simulation Results on Missing R&D Test

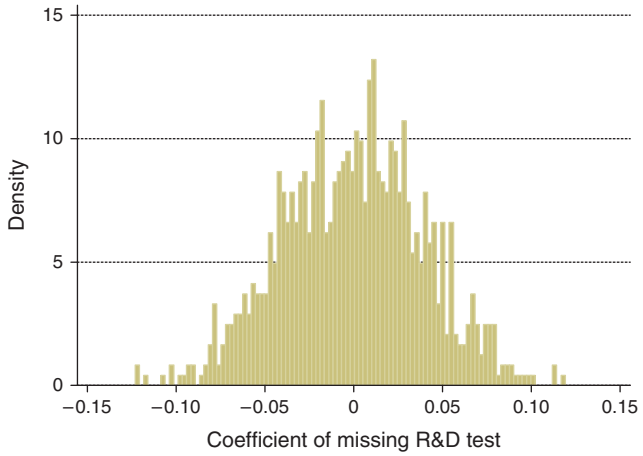
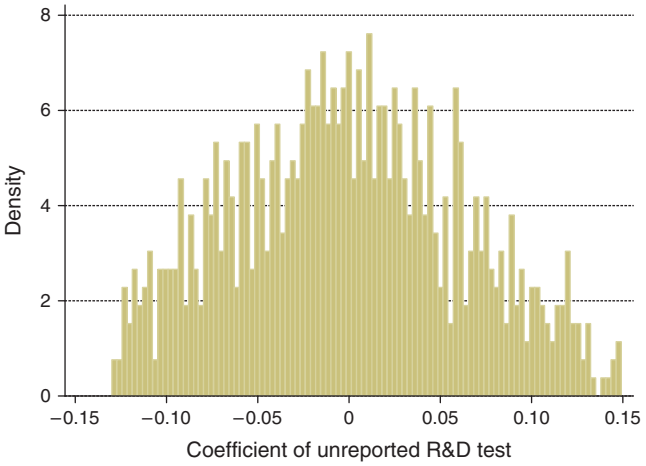


Figure 1(b). (Color online) Simulation Results on Unreported R&D Test



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 from the simulation (−0.130). 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 staggered U.S. state courts' verdict on the IDD as the exogenous shock to the protection of the firm's human capital and trade secrets from employee movement to rival firms (Png and Samila 2015). 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.[9] 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 assign firms to a state based on the location of their corporate headquarters, consistent with Malecki (1979), who report that R&D facilities are commonly located near corporate headquarters.

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 unreported R&D firm) because the IDD provides another layer of protection from rivals. By 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 unreported 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 unreported R&D firms and CEO type around the years of IDD adoption based on our matched sample.[10] Figure 2(a) shows the percentage of unreported R&D firms among confident CEOs who operate in states that adopted IDD versus states that did not. We observe that the adoption of IDD has a 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 unreported 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). By 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 unreported R&D is observed in subsequent years.

In Figure 2(b), 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 unreported R&D firms with confident CEOs between states with and without IDD adoption (i.e., dashed line less dotted line in Figure 2(a). This results in the dashed line in Figure 2(b). The pre-/post-IDD adoption represents the second difference dimension. For comparison, we similarly present the outcomes for cautious CEOs (see the dotted line). For firms with confident CEOs (dashed line), we continue to observe a sharp drop in the proportion of unreported R&D

Figure 2(a). Confident CEO and Unreported R&D Firms: Pre- and Post-IDD Shock

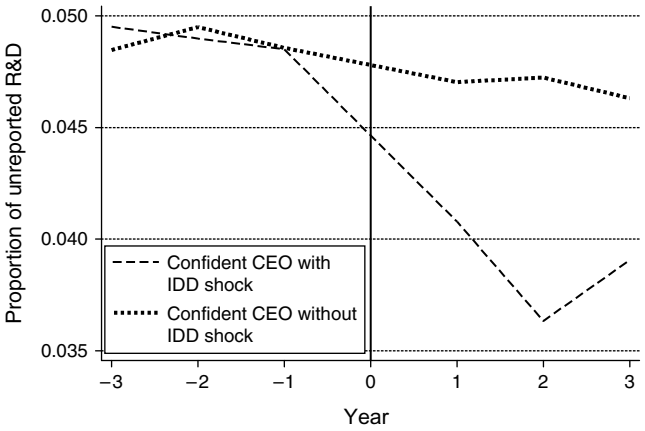
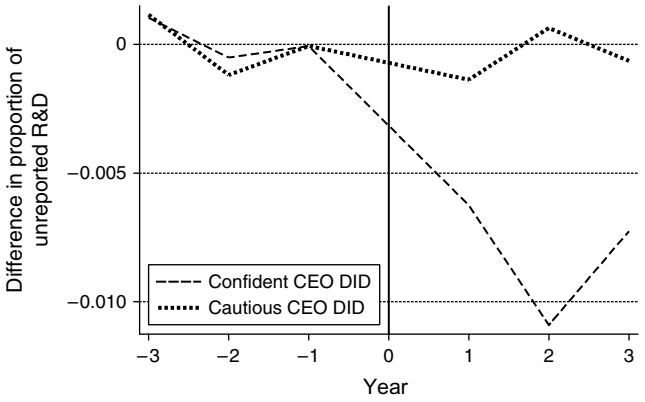


Figure 2(b). CEO Type and Unreported R&D Firms: Pre- and Post-IDD Shock (Difference-in-Differences)



firms in the first year of IDD adoption (year 0). This decline continues until two years after the IDD adoption. The proportion of unreported R&D firms is lower in the post-IDD period relative to the pre-IDD adoption period.

By contrast, for cautious CEOs (dotted line), the proportion of unreported 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 unreported R&D firms decrease more among confident CEO firms after IDD adoption than among cautious CEO firms (*t*-statistics for the difference-in-differences (DID) > 2.25 in both full and matched samples).

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

$$\begin{aligned}\text{Prob}(Y) = f(&\textit{Confident}, \textit{IDD}, \textit{Confident} \times \textit{IDD}, \textit{Firm Size},\\ &\textit{Leverage}, \textit{ROA}, \textit{Market-to-book}, \textit{Volatility},\\ &\textit{Inst\_own}, \textit{CEO Delta}, \textit{CEO Vega}\\ &\textit{Industry Competition}, \textit{Stock Return},\\ &\text{Industry and year fixed effects}), \end{aligned} \quad (2)$$

where Y equal to 1 indicates an unreported R&D firm; *IDD* equals 1 if the state has IDD in effect during that year.[11] 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.[12]

In columns (1) and (2), we present the results based on our full sample, focusing on whether firms choose to be unreported R&D firms. Consistent with our findings in Table 2, we find that CEO confidence is negatively associated with being unreported R&D firms ($|z\text{-statistics}| > 2.19$). We find IDD adoption has a significantly positive effect on being unreported R&D firms ($|z\text{-statistics}| > 2.44$). For our variable of interest, *Confident* × *IDD*, it is negative and significant (column (2); z-statistics = −2.26), indicating that in states with IDD protection, a confident CEO is less likely to hide his or her R&D expenditures (by being an unreported 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 the matched control firms do not experience an 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 unreported R&D firms ($|z\text{-statistics}| = 2.02$). Economically, we find that CEO confidence is associated with a 26% lower probability of being an unreported R&D firm. Furthermore, on average, firms are more likely to be unreported R&D firms after the state adopts IDD protection of trade secrets (z-statistics = 2.30). This is 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 a 17% lower probability of the firm being an unreported R&D firm. Finally, we find that the interaction term

Table 3. IDD Restrictions, CEO Confidence, and R&D Disclosure

Panel A: Proportion of unreported R&D firms

	Full sample			Matched sample		
CEO type:	Confident	Cautious	*t*-test	Confident	Cautious	*t*-test
	(1)	(2)	(3)	(4)	(5)	(6)
No IDD	0.048	0.078	3.10***	0.057	0.077	2.80***
IDD	0.038	0.077	3.91***	0.045	0.073	3.11***
t-test	2.10**	0.20	2.50**	2.32**	0.55	2.25**

Panel B: IDD restrictions, CEO confidence, and unreported R&D

Dependent variable:	*Unreported R&D*			
	Full sample		Matched sample	
	(1)	(2)	(3)	(4)
Constant	−1.880***	−1.928***	−0.667	−1.115
	(−3.21)	(−3.29)	(−0.90)	(−1.32)
Confident	−0.261**	−0.157**	−0.330**	−0.287**
	(−2.19)	(−2.19)	(−2.02)	(−2.19)
IDD	0.380**	0.542***	0.332**	0.427**
	(2.44)	(3.14)	(2.30)	(2.15)
Confident × *IDD*	—	**−0.456****	—	**−0.229****
		(−2.26)		**(−2.22)**
Firm Size	0.377***	0.377***	0.322*	0.299*
	(5.79)	(5.79)	(1.92)	(1.72)
Leverage	−0.530	−0.511	−0.590	−0.572
	(−1.41)	(−1.36)	(−0.75)	(−0.96)
ROA	0.766	0.769	1.210	1.335
	(0.98)	(0.98)	(0.89)	(0.90)
Market-to-book	−0.105	−0.106	−0.122	−0.119
	(−1.34)	(−1.35)	(−1.39)	(−1.42)
Volatility	−2.029**	−2.030**	−1.589	−1.602
	(−1.98)	(−1.97)	(−0.90)	(−0.91)
Inst_own	0.087	0.086	0.156	0.159
	(0.36)	(0.35)	(0.67)	(0.68)
CEO Delta	−0.027	−0.027	0.220	0.222
	(−0.55)	(−0.56)	(0.72)	(0.70)
CEO Vega	−0.035*	−0.035*	−0.106	−0.105
	(−1.83)	(−1.83)	(−1.39)	(−1.41)
Industry Competition	−2.416*	−2.426*	−3.902	−3.911
	(−1.72)	(−1.72)	(−1.45)	(−1.47)
Stock Return	−0.142***	−0.142***	−0.029	−0.028
	(−3.32)	(−3.32)	(−0.70)	(−0.71)
Industry and year dummy	Yes	Yes	Yes	Yes
Observations	13,094	13,094	358	358
Pseudo R^2	0.266	0.267	0.351	0.351

Notes. This table presents results examining the incremental effect of CEO confidence on R&D disclosure, comparing the difference before and after states adopting IDD versus states that keep the same legislation. IDD is a dummy variable that equals 1 when the IDD is adopted in the state. We match firms within the same industry-year combination 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, prior stock return, and the number of patents. All variables are defined in the appendix. 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 * indicate significance at the 1%, 5%, and 10% levels, respectively.

Confident × *IDD* is significantly negative (column (4); |*z*-statistics| = 2.22), suggesting that relative to cautious CEOs, confident CEOs are less likely to hide R&D disclosure (11% 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 more confident about delivering their expected future performance due to the added intellectual property protection.

In addition to assigning firms to states based on their corporate headquarters, we also alternatively assign firms to states based on the most commonly listed state in the firms' patent applications for their inventors. Consistent with prior literature that documents most R&D facilities are commonly located near corporate headquarters (Malecki 1979), we find that the majority of patents are actually filed from the same state as the corporate headquarters. Using this alternative assignment procedure, we rerun our Table 3 analysis, and the untabulated results show that our variable of interest, *Confident* × *IDD*, is significantly negative ($|z\text{-statistics}| = 2.31$), suggesting our main finding is robust to using patent applicants' location in the assignment process, largely because of the concentration of patent applicants in the same state as the corporate headquarters.

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 within the same industry-year combination 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, stock return, and the number of patents, using a caliper of 0.1% without replacement. We identify 78 cases of confident CEO dismissals and 78 cautious CEO dismissals for the test.[13] We include a three-year window prior to and after the turnover in our regression. Our empirical approach adopts a change specification as follows:

$$\begin{aligned}\Delta Y = f(&\textit{Confi-Confi, Confi-Cautious, Cautious-Confi,}\\ &\Delta\textit{Firm Size, }\Delta\textit{Leverage, }\Delta\textit{ROA,}\\ &\Delta\textit{Market-to-book, }\Delta\textit{Volatility, }\Delta\textit{Inst\_own,}\\ &\Delta\textit{CEO Delta, }\Delta\textit{CEO Vega,}\\ &\Delta\textit{Industry Competition, }\Delta\textit{Stock Return,}\\ &\text{Industry fixed effects}),\end{aligned} \tag{3}$$

where ΔY is the change in unreported R&D disclosure in pre- versus post-CEO-turnover periods. *Confi-Confi* represents confident CEOs in both preturnover and postturnover periods; *Confi-Cautious* (*Cautious-Confi*) indicates a change in CEO type from confident (cautious) in the preturnover period to cautious (confident) in the postturnover period. All other variables are measured as the difference between the pre- and post-CEO-turnover periods 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.[14]

We present the results in Table 4. Panel A shows univariate test results covering before and after a 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 unreported R&D firms between preturnover and postturnover periods (t-statistics < 0.55). Difference-in-differences tests indicate that the incidence of unreported R&D in firms with the same type of CEO before and after the turnover remains unchanged (t-statistics = 0.20). By contrast, firms that change from a confident CEO to cautious CEO result in a significant increase in the incidence of unreported R&D (t-statistics = 2.40), while a change from cautious to confident CEOs results in a significant decline in incidence of the unreported R&D (t-statistics = 2.49).[15] In columns (4)–(6), we show that among firms that have a confident CEO before the turnover, firms that change to a cautious CEO observe greater incidence of unreported R&D firms than those that have a new CEO who is confident (t-statistics for difference-in-differences = 2.06). Finally, in columns (7)–(9), we find that firms that have cautious CEOs before the turnover experience lower incidences of unreported R&D firms if they change to a confident CEO than if they hire the same type of CEO (t-statistics for difference-in-differences= 2.33).

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 unreported R&D firms after CEO turnover (t-statistics = −1.30). Moreover, firms with a CEO type change from confident to cautious (*Confi-Cautious*) are more likely to be unreported R&D firms after the turnover than in the preturnover period (t-statistics = 2.37). Finally, firms with a CEO type change from cautious to confident (*Cautious-Confi*) are less likely to be unreported R&D firms after the turnover than in the preturnover period (t-statistics = −2.28).

We next conduct F-tests to compare the effect between the different types of CEO change. More specifically, we find that firms with a change in CEO type from confident to cautious (*Confi-Cautious*) are more likely to be unreported R&D firms after the turnover than in the preturnover period more so than those that have confident CEOs before and after CEO turnover (*Confi-Confi*; F-statistics = 6.62). By contrast,

Table 4. CEO Turnover, CEO Confidence, and R&D Disclosure: Multinomial Logit Regression

Panel A: Proportion of unreported R&D firms

	Confident vs. cautious CEO turnover			Confident CEO turnover vs. nonturnover			Cautious CEO turnover vs. nonturnover		
	Pre	Post	*t*-test	Pre	Post	*t*-test	Pre	Post	*t*-test
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Confi-Confi	0.055	0.053	0.55	0.055	0.055	0.10	—	—	—
Confi-Cautious	0.053	0.058	2.40**	0.055	0.058	2.00**	—	—	—
Cautious-Confi	0.058	0.052	2.49**	—	—	—	0.058	0.052	2.41**
Cautious-Cautious	0.059	0.059	0.10	—	—	—	0.059	0.059	0.12
Tests of differences									
Confi-Confi vs. Confi-Cautious	0.29	2.40**	2.18**	0.25	2.22**	2.06**	—	—	—
Confi-Confi vs. Cautious-Confi	2.62***	1.09	2.11**	—	—	—	—	—	—
Confi-Confi vs. Cautious-Cautious	2.66***	2.69***	0.20	—	—	—	—	—	—
Confi-Cautious vs. Cautious-Confi	2.65***	2.10**	3.00***	—	—	—	—	—	—
Confi-Cautious vs. Cautious-Cautious	3.15***	1.88*	2.31**	—	—	—	—	—	—
Cautious-Confi vs. Cautious-Cautious	0.42	2.38**	2.11**	—	—	—	0.55	2.37**	2.33**

Panel B: Multivariate test

Dependent variable:	*ΔUnreported R&D*		
	Confident CEO vs. cautious CEO turnover	Confident CEO turnover vs. nonturnover	Cautious CEO turnover vs. nonturnover
	(1)	(2)	(3)
Constant	0.072 (1.22)	0.068 (1.10)	0.042 (1.29)
Confi-Confi (β_1)	**−0.015** **(−1.30)**	**−0.020** **(−0.99)**	—
Confi-Cautious (β_2)	**0.025**** **(2.37)**	**0.038**** **(2.06)**	—
Cautious-Confi (β_3)	**−0.022**** **(−2.28)**	—	**−0.027**** **(−2.39)**
Cautious-Cautious (β_4)	—	—	**0.002** **(0.32)**
ΔFirm Size	−0.050 (−1.29)	−0.023 (−1.42)	−0.022 (−1.50)
ΔLeverage	0.033 (0.89)	0.042 (1.02)	0.039 (0.99)
ΔROA	0.018 (0.55)	0.022 (0.90)	0.028 (0.88)
ΔMarket-to-book	−0.004 (−1.29)	−0.004 (−1.27)	−0.005 (−1.02)
ΔVolatility	0.096 (1.20)	0.090 (0.92)	0.089 (1.00)
ΔInst_own	0.056 (1.50)	0.077 (1.60)	0.055 (1.43)
ΔCEO Delta	0.009 (1.42)	0.005 (1.11)	0.006 (1.30)
ΔCEO Vega	−0.011 (−1.20)	−0.011 (−1.39)	−0.012 (−1.52)
ΔIndustry Competition	0.011 (0.45)	0.012 (0.70)	0.010 (0.56)
ΔStock Return	−0.022 (−1.60)	−0.028 (−1.55)	−0.026 (−1.43)

Table 4. (Continued)

Panel B: Multivariate test (continued)			
Dependent variable:	*ΔUnreported R&D*		
	Confident CEO vs. cautious CEO turnover	Confident CEO turnover vs. nonturnover	Cautious CEO turnover vs. nonturnover
	(1)	(2)	(3)
Industry dummy	Yes	Yes	Yes
Observations	156	122	182
Chi-squared	45.32	55.29	63.02
F-test:			
Confi-Confi vs. *Confi-Cautious* ($\beta_1 = \beta_2$)	6.62**	4.52**	—
Confi-Confi vs. *Cautious-Confi* ($\beta_1 = \beta_3$)	0.22	—	—
Confi-Cautious vs. *Cautious-Confi* ($\beta_2 = \beta_3$)	10.80***	—	—
Cautious-Cautious vs. *Cautious-Confi* ($\beta_3 = \beta_4$)	—	—	4.96**

Notes. We present results based on a propensity-score-matched sample of confident and cautious CEOs 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, prior stock return, number of patents, and industry-year combination. In panel A, the sample represents 78 cases of confident CEO turnover and 78 cautious CEO turnovers for our test. In panel B, we match firms with confident (cautious) CEO that experience turnover versus those that do not. All variables are defined in the appendix. 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 * indicate significance at the 1%, 5%, and 10% levels, respectively.

firms that have a CEO type change from cautious to confident (*Cautious-Confi*) are less likely to be unreported R&D firms after the turnover than before the turnover more so than those that change from confident to cautious (*Confi-Cautious*) after CEO turnover (*F*-statistics = 10.80). Collectively, our difference-in-differences results indicate that a change in CEO type is associated with an R&D disclosure choice where a confident (cautious) CEO who replaces a cautious (confident) CEO is less (more) likely to be in an unreported 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 have 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 in unreported R&D firms) in comparison to their confident predecessors and to firms without CEO turnover (column (2); *t*-statistics = 2.06). This relation holds even when we compare firms that replace a confident CEO with another confident CEO (*F*-statistics = 4.52). For the latter, we also find no evidence that their choice of being unreported R&D firms changed compared with firms without CEO turnover (*t*-statistics = −0.99).

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 unreported R&D firms. This is true irrespective of whether they are compared with firms without CEO turnover (*t*-statistics = −2.39) or with firms that replace a cautious CEO with another cautious CEO (*F*-statistics = 4.96). Finally, the unreported R&D 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= 0.32).

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

3.4. Disclosure Reform Shocks: Regulation Fair Disclosure and Sarbanes–Oxley Act

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). Because of these limits on selective disclosure in the postdisclosure 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 unreported 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 predisclosure and postdisclosure reform periods in Table 5. To capture effects from both the Regulation FD in 2000 and Sarbanes–Oxley (SOX) Act in 2002, we treat years 2000–2002 as transition years and drop them from our test. In panel A, we present univariate test results for full and matched samples. In general, we find in both samples that (1) consistent with Table 2 results, confident CEOs are less likely to be in unreported firms than cautious CEOs in both the predisclosure and postdisclosure eras (t-statistics > 2.20), and (2) despite both confident and cautious CEO firms being less likely to be unreported R&D firms after regulatory change (t-statistics > 2.27), confident CEOs experience smaller change in the proportion of unreported R&D firms than cautious CEOs (t-statistics for the difference-in-differences > 2.21), where on average the effects on cautious CEO firms are about 35% greater than for confident CEO firms.

Panel B reports the multivariate tests where we modify Equation (2) using a dummy variable, *Postdisclosure*, 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 in unreported R&D firms than cautious CEOs in the predisclosure era ($|z$-statistics$|$ > 1.76), but they are insignificantly different from the latter in the postdisclosure era (F-statistics < 1.33). Moreover, the interaction term, *Confident* × *Postdisclosure*, is positive and significant (z-statistics > 2.28), 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 22%–36% decrease in R&D disclosure bias (namely, the proportion of unreported 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 35%–48% in the postreform period. We use these high (predisclosure reform) and low (postdisclosure reform) periods of R&D disclosure bias to evaluate the role of disclosure bias on R&D investment between confident and cautious CEO firms.[16]

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 > 3.19) in both full and matched sample tests during the high R&D disclosure bias period, and (2) confident CEO firms exhibit a lower proportion of positive R&D firms than cautious CEO firms (t-statistics > 4.02) 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 tests using R&D expenditure as the dependent variable. Here, to mitigate or control for the bias in R&D disclosure, we replace the missing R&D values with zero, industry-average value, 0.5% of sales, or interpolated R&D investment.[17] In addition, to be comparable to Hirshleifer et al. (2012, table 4), we adopt the same control variables and standardize all continuous independent variables as well. 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> 1.83), consistent with the study by Hirshleifer et al. (2012) that uses a sample largely comprising the same time period. By contrast, panel C shows that after the regulatory change, a confident CEO is negative but insignificantly associated with R&D expenditure ($|t$-statistics$|$ < 1.39). Finally, our tests between the coefficients indicate that the effect of CEO confidence on R&D expenditure is significantly different between the high and low disclosure bias periods (F-statistics > 2.82).

Interestingly, we find that missing R&D denotation is negatively associated with R&D when a missing R&D value is replaced by zero, a small amount, or interpolated values (see columns (2), (4), and (6) in panels B and C); it is positively associated with R&D when industry averages are used to replace missing R&D values (columns (3) and (5) in panels B and C). These seem to suggest that the true R&D expenditure of firms with missing R&D values is on average between 0.5% of sales and their industry average. The relative magnitude of the coefficients further suggests that the average true R&D expenditure of firms with missing R&D values is closer to the industry average than to 0.5% of sales.

Table 5. CEO Confidence and R&D Opacity: Effects of Disclosure Reform

Panel A: Proportion of unreported R&D firms

	Full sample			Matched sample		
CEO type:	Confident	Cautious	t-test	Confident	Cautious	t-test
	(1)	(2)	(3)	(4)	(5)	(6)
Predisclosure	0.054	0.085	5.39***	0.071	0.105	2.61***
Postdisclosure	0.042	0.057	3.00***	0.052	0.067	2.20**
t-test	2.32**	5.22***	2.28**	2.27**	2.72***	2.21**

Panel B: Regression result

Dependent variable:	*Unreported R&D*	
	Full sample	Matched sample
	(1)	(2)
Constant	−6.363***	−2.998***
	(−5.16)	(−2.89)
Confidence (β_1)	−0.282*	−0.211**
	(−1.76)	(−2.11)
Postdisclosure (β_2)	−0.416**	−0.509**
	(−2.36)	(−2.37)
Confident × *Postdisclosure* (β_3)	0.176**	0.188**
	(2.32)	(2.28)
Firm Size	0.383***	0.501**
	(6.20)	(2.45)
Leverage	−0.426	−0.290
	(−1.15)	(−0.50)
ROA	0.469	1.782
	(0.53)	(1.09)
Market-to-book	−0.012	−0.052*
	(−0.73)	(−1.90)
Volatility	−1.523	−2.838
	(−1.27)	(−0.96)
Inst_own	0.229	0.902
	(0.93)	(1.55)
CEO Delta	−0.028	0.211
	(−0.55)	(1.02)
CEO Vega	−0.061	−0.320**
	(−1.34)	(−2.18)
Industry Competition	−1.230	−1.925
	(−1.07)	(−1.39)
Stock Return	−0.157***	−0.476**
	(−2.84)	(−2.39)
Industry and year dummy	Yes	Yes
Observations	10,192	582
Pseudo R^2	0.229	0.435
Tests of differences (F-test):		
Postdisclosure (*Confi* − *Cautious*) ($\beta_1 + \beta_3 = 0$)	1.322	0.323
Confi (*Postdisclosure* − *Predisclosure*) ($\beta_2 + \beta_3 = 0$)	1.561	9.022**

Notes. This table presents results of the effect of CEO confidence on R&D disclosure choice. *Predisclosure* (*Postdisclosure*) is a dummy variable equal to 1 indicating the time period before 2000 (after 2002) and equal to 0 for the period after 2002 (before 2000). Panel A presents the univariate test. Panel B shows regression results. All variables are defined in the appendix. 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 * indicate significance at the 1%, 5%, and 10% levels using two-tailed tests, respectively.

Table 6. CEO Confidence and R&D Expenditures

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

	Full sample			Matched sample		
CEO type:	Confident	Cautious	*t*-test	Confident	Cautious	*t*-test
High Bias	0.835	0.783	4.70***	0.962	0.901	3.19***
Low Bias	0.773	0.833	5.50***	0.908	0.971	4.02**
t-test	5.28***	4.90***	9.28***	2.44***	2.72***	6.11***

Panel B: High R&D disclosure bias

	Dependent variable = *R&D expenditures/TA*					
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	−0.002	0.019***	0.008**	0.021***	0.009**	0.020***
	(−0.31)	(3.30)	(2.12)	(3.85)	(2.33)	(6.49)
Confident	**0.004****	**0.005****	**0.004***	**0.005****	**0.004***	**0.006*****
	(1.98)	**(2.36)**	**(1.83)**	**(2.49)**	**(1.86)**	**(2.67)**
Missing R&D	—	−0.027***	0.004**	−0.021***	0.003*	−0.029***
		(−12.13)	(2.29)	(−9.24)	(1.79)	(−11.97)
Unreported R&D	—	—	—	—	0.003	0.008***
					(1.32)	(3.22)
Controls, industry, and year dummy	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,599	6,599	6,599	6,599	6,599	6,599
Adjusted R^2	0.532	0.560	0.583	0.543	0.586	0.562
Replacing missing R&D with:	Zero	Zero	Ind. avg.	0.5% of sales	Ind. avg.	Interpolated

Panel C: Low R&D disclosure bias

	Dependent variable = *R&D expenditures/TA*					
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	−0.002*	−0.003	−0.002	0.019	−0.007	0.004
	(−1.71)	(−0.03)	(−0.78)	(0.19)	(−0.27)	(1.16)
Confident	**−0.003**	**−0.002**	**−0.001**	**−0.002**	**−0.001**	**−0.002**
	(−1.39)	**(−1.14)**	**(−0.41)**	**(−1.26)**	**(−0.67)**	**(−1.27)**
Missing R&D	—	−0.029***	0.007***	−0.023***	0.006***	−0.031***
		(−13.62)	(4.15)	(−10.88)	(3.40)	(−13.34)
Unreported R&D	—	—	—	—	0.004**	0.006***
					(2.54)	(2.78)
Controls, industry, and year dummy	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,082	6,082	6,082	6,082	6,082	6,082
Adjusted R^2	0.489	0.524	0.539	0.511	0.551	0.538
Replacing missing R&D with:	Zero	Zero	Ind. avg.	0.5% of sales	Ind. avg.	Interpolated

Panel D: Difference-in-differences analysis

	(1)	(2)	(3)	(4)	(5)	(6)
F-test: *Confident* (panel B) = *Confident* (panel C)	5.63***	6.50***	2.82*	7.51***	3.62**	8.39***

Notes. This table presents results of CEO confidence on firms' R&D investment. The dependent variable is R&D expenditure divided by total assets (TA). 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 panels B and C, we replace missing R&D values with zero, industry average, 0.5% of sales, or interpolated values, respectively. All continuous independent variables are standardized. All independent variables are defined in the appendix and take a one-year lagged value. The *t*-statistics provided in parentheses are adjusted for heteroskedasticity using the Huber–White sandwich estimator and are corrected for clustering of firm effects.

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

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, B, and 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

Table 7. CEO Confidence and Patent Activity

CEO type:	Full sample			Matched sample		
	Confident	Cautious	*t*-test	Confident	Cautious	*t*-test
	(1)	(2)	(3)	(4)	(5)	(6)
			Panel A: Proportion of firms with patents			
High Bias	0.448	0.418	2.62***	0.736	0.674	4.02***
Low Bias	0.410	0.454	3.20***	0.667	0.750	4.89***
t-test	2.84***	3.02***	6.77***	4.30***	4.45***	8.16***
			Panel B: Number of patents per firm			
High Bias	14.670	8.998	4.16***	38.918	29.906	3.30***
Low Bias	5.625	11.019	4.51***	19.467	33.837	4.29***
t-test	6.40***	1.73*	8.22***	5.01***	2.11**	6.39***
			Panel C: Citations per firm			
High Bias	277.230	156.960	4.20***	314.413	197.764	4.78***
Low Bias	67.746	151.485	3.55***	114.134	182.103	2.70***
t-test	8.07***	0.21	6.97***	6.29***	1.02	5.56***

Notes. The table presents univariate results regarding patents and citations by CEO type. *High Bias* (*Low Bias*) indicates the time period before 2000 (after 2002). All variables are defined in the appendix.

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

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 the full sample and matched sample (*t*-statistics > 6.77), suggesting cautious CEOs are more likely to have patent activities in the low R&D disclosure bias period than in the high R&D disclosure bias period compared with 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 significant increases in patents (*t*-statistics > 1.73) and no significant change in citations (*t*-statistics < 1.02) after the regulatory change. By contrast, confident CEOs' patents and citations decreased drastically after the regulatory change (*t*-statistics > 5.01), where they ended up having significantly fewer patents and citations than their cautious counterparts (*t*-statistics > 2.70). We find the difference-in-differences are all significant (*t*-statistics > 5.56).

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 the 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 the evidence in Table 6 indicates that the average true R&D expenditure of firms with missing R&D values is closer to their industry averages, we replace missing R&D values with their industry averages for our tests here.[18] We adopt the specifications in Tables 5 and 6 of Hirshleifer et al. (2012), where all continuous independent variables are standardized. One notable difference is that we explicitly control for the level of R&D by the accumulated R&D stock measure in Galasso and Simcoe (2011). We include the interaction term of *R&D Stock* with *Confident* but also show results without.[19]

We find evidence that confident CEOs are negatively associated with patent applications and citations in the low R&D disclosure bias period (columns (1)–(4); |*t*-statistics| > 3.03), while in the high disclosure bias period, no significant relation is found (columns (5)–(8); |*t*-statistics| < 1.43). Not surprisingly, we find that *R&D Stock* is significantly positively related to both patent applications and citations in seven out of eight specifications (*t*-statistics > 2.05). We also find evidence consistent with the notion that the R&D stock of confident CEOs is positively associated with patent applications and citations in the high disclosure bias era (*Confident* × *R&D Stock* in columns (6) and (8); *t*-statistics > 1.82) but becomes insignificant or negative in the low disclosure bias era (*Confident* × *R&D Stock* in columns (2) and (4); *t*-statistics = −1.06 and −2.16, respectively). Finally, our analysis reveals that both *Confident* and *Confident* × *R&D Stock* are significantly lower in the low disclosure bias period than in the high disclosure bias period (*F*-statistics > 4.41).

Recent studies suggest that confident CEOs potentially take less risk relative to cautious CEOs in the post-SOX period (e.g., Banerjee et al. 2015). Consequently, one potential alternative explanation for the results in Table 8 centers on either changes in the proportion of confident to cautious CEOs or a greater

Table 8. CEO Confidence and Corporate Patent Applications and Citations

	Low Bias				*High Bias*			
Dependent variable:	log(1 + *Patent app.*)		log(1 + *Citations*)		log(1 + *Patent app.*)		log(1 + *Citations*)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Constant	1.213***	1.260***	1.040***	1.083***	2.254***	2.260***	2.192***	2.184***
	(6.74)	(7.15)	(5.75)	(5.96)	(12.49)	(12.48)	(11.53)	(11.62)
Confident	−0.202***	−0.275***	−0.222***	−0.283***	0.020	0.030	0.132	0.082
	(−4.09)	(−5.49)	(−3.03)	(−3.87)	(0.36)	(0.54)	(1.43)	(0.88)
R&D Stock	0.415***	0.367***	0.288***	0.248***	0.377***	0.303***	0.181**	0.107
	(5.79)	(5.68)	(5.30)	(5.04)	(3.81)	(3.12)	(2.05)	(1.50)
Confident × *R&D Stock*	—	**−0.060**	—	**−0.103****	—	**0.135***	—	**0.135****
		(−1.06)		**(−2.16)**		**(1.82)**		**(2.40)**
Missing R&D	−0.736***	−0.716***	−0.577***	−0.560***	−0.788***	−0.774***	−1.030***	−1.017***
	(−11.28)	(−11.27)	(−5.57)	(−5.46)	(−11.27)	(−11.38)	(−7.79)	(−7.76)
Firm Size (log sales)	0.386***	0.368***	0.524***	0.508***	0.579***	0.565***	0.339***	0.324***
	(8.48)	(8.40)	(8.95)	(8.84)	(12.43)	(13.38)	(4.89)	(4.78)
PPE/EMP (log)	−0.044	−0.044	−0.003	−0.004	−0.097**	−0.096**	−0.039	−0.039
	(−1.22)	(−1.24)	(−0.06)	(−0.07)	(−2.08)	(−2.05)	(−0.42)	(−0.42)
Inst_own	0.019	0.024	−0.023	−0.018	0.074**	0.073**	0.274***	0.273***
	(0.70)	(0.91)	(−0.61)	(−0.49)	(2.18)	(2.18)	(4.80)	(4.80)
CEO Tenure	−0.018	−0.019	0.021	0.020	−0.021	−0.021	−0.035	−0.034
	(−0.98)	(−1.08)	(0.72)	(0.67)	(−1.08)	(−1.07)	(−0.92)	(−0.92)
CEO Delta	0.051*	0.046	−0.009	−0.014	0.041	0.039	0.128**	0.126**
	(1.65)	(1.50)	(−0.21)	(−0.31)	(1.26)	(1.21)	(2.19)	(2.15)
CEO Vega	0.150***	0.145***	0.075*	0.072*	0.105***	0.109***	0.217***	0.221***
	(5.23)	(5.08)	(1.84)	(1.76)	(3.14)	(3.21)	(3.68)	(3.72)
Stock Return	−0.030**	−0.027**	−0.014	−0.011	−0.029	−0.027	−0.062	−0.060
	(−2.18)	(−1.98)	(−0.62)	(−0.51)	(−1.28)	(−1.22)	(−1.32)	(−1.28)
Industry and year dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,599	6,599	6,599	6,599	6,082	6,082	6,082	6,082
Adjusted R^2	0.562	0.572	0.290	0.295	0.632	0.636	0.401	0.404

Difference-in-differences (*F*-tests)	Col. (1) vs. (5)	Col. (2) vs. (6)	Col. (3) vs. (7)	Col. (4) vs. (8)
Confident	8.91***	16.22***	9.12***	9.55***
Confident × *R&D Stock*		4.41**		10.55***

Notes. The table presents ordinary least squares regression results on the effect of R&D investment on R&D performance by the CEO type. *High Bias* (*Low Bias*) indicates years before 2000 (after 2002). All variables are defined in the appendix and are one-year-lagged value. All continuous independent variables are standardized. The *t*-statistics provided in parentheses are adjusted for heteroskedasticity using the Huber–White sandwich estimator and are corrected for clustering of firm effects.

***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

decline in actual R&D by confident relative to cautious CEOs. We first assess whether the proportion of confident CEO firms changes in each industry of our analysis. Among the 19 industries (two-digit SIC codes) in our sample with the most confident CEOs, three industries experience a significant increase in the proportion of confident CEOs. After dropping these three industries, we again find results similar to those reported in Table 8, suggesting our findings are not driven by changes in the industry composition of confident/cautious CEOs.

Second, our specifications for Table 8 tests include an interaction term, *Confident* × *R&D Stock*, to specifically capture the effects of risk taking (in the form of R&D), in addition to controlling for the level of CEO confidence. Our findings in columns (2), (4), (6), and (8) can be interpreted in the context of incremental effects of confident CEOs with increasing risk-taking behavior (in the form of R&D). Our findings from this direct approach to incorporating the risk-taking behaviors rule out the alternative risk-reduction argument explanation. Furthermore, in the high R&D disclosure bias period, the incremental sensitivity of patents and citations to risk taking in R&D is roughly 10.5% higher in confident CEO firms than in cautious CEO firms, as shown by the interaction term in Table 8, columns (6) and (8). Similarly, in the low disclosure bias period, after controlling for R&D, the marginal effect of R&D on patents (citations) is roughly 5% (8.2%) lower in confident CEO firms than in cautious CEO firms (see Table 8, columns (2) and (4)). Moreover, these effects

are significantly different between the two periods, as reported in the last row of Table 8.

We also control for patenting activities in our regression specifications for the citation analysis to capture changes in risk-taking behavior in the form of patent applications. Results in Internet Appendix B show that CEO confidence switches from insignificantly positive in the high disclosure bias period ($|t\text{-statistics}| \leq 1.01$) to significantly negative in the low disclosure bias period ($|t\text{-statistics}| \geq 2.21$). The difference between the two periods is statistically significant (F-statistics ≥ 7.15). Moreover, the interaction term, *Confident* × *R&D Stock*, also switches from significantly positive in the high disclosure bias period ($|t\text{-statistics}| = 2.64$) to significantly negative in the low disclosure bias period ($|t\text{-statistics}| = 2.21$), with the difference between the two periods being highly significant (F-statistics $= 23.59$). Taken together, after controlling for the risk-taking effect in R&D and patenting activities, we find that CEO confidence contributes a differential effect between the R&D–patents/citations relationships.

Third, we circumvent the concern that confident CEOs change their risk-taking behavior post-SOX by entirely bypassing its potential influence on our test specifications. More specifically, we focus solely on the pre-SOX period to address the missing R&D data problem by using three different statistical approaches (inverse probability weighting (IPW), the Heckman selection model, and multiple imputation) to adjust for the missing R&D data. We present the results in Internet Appendix C. Column (1) shows the classic positive relation between CEO confidence and patents noted by prior studies when missing R&D is replaced by zero. Next, we repeat the analysis using IPW, Heckman, and multiple imputation models to adjust for the disclosure bias rather than simply recoding the missing R&D observations. The results demonstrate that after adjusting for the disclosure bias using IPW, Heckman, and multiple imputation, we find no discernable relation between managerial confidence and patent applications in the pre-SOX era ($|t$ -statistics$| \leq 1.47$). In short, the results from prior studies of a positive relation arise probably because confident CEOs exhibit a greater propensity to report their innovation activities relative to their cautious CEO counterparts.

In sum, our evidence suggests that it is difficult to infer the influence of CEO confidence on corporate R&D decisions and performance using financial statement information without considering the effect of this bias on mandatory disclosures. Intuitively, the problem arises because failures to disclose innovation do not occur randomly but instead are related to managerial confidence.

5. Additional Robustness Testing

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% and 150%. We find that results using these higher thresholds for CEO confidence are associated with stronger results; that is, we find that firms with confident CEOs are even less likely to be unreported R&D firms than those with cautious CEOs when measuring confidence using these more stringent thresholds. For instance, we find that the CEO confidence measure using a 100% moneyness threshold is associated with a 28% (31%) lower probability of a firm being an unreported 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). The first one is *Longholder*, which indicates that if a CEO during our sample period still holds option in the year of expiration that is at least 40% in-the-money, then we designate this CEO as confident. The second measure, *Netbuyer*, is calibrated as follows: First, we require that 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 he or she sells 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 testing. We yield 230 unique CEOs in our sample, 140 of whom 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 confident CEOs are more negatively associated with being unreported R&D firms than are cautious CEOs. Economically, for instance, we find that a *Netbuyer* CEO is associated with a 51% lower probability of being from an unreported R&D firm than a non-*Netbuyer* CEO would be.

5.3. Alternative Matched Samples

Our main matched sample is relatively small because we imposed a substantial number of restrictions to ensure we developed valid counterfactual firms. Consequently, we repeat our main tests using an alternative matched sample with fewer restrictions, yielding similar findings and inferences to our main results (see Internet Appendix D). We also incorporated two alternative matching methods. Specifically, both

Mahalonobis distance matching and coarsened exact matching procedures generate alternative resulting matched samples yet continue to yield consistent inferences to our main results. Taken together, our main results and inferences are not sensitive to alternative matching criteria or matching techniques.

5.4. Firm Fixed Effects

We use an alternative specification to check the effect of CEO type change on a firm's R&D disclosure. More specifically, we replace industry fixed effects in Table 2 with firm fixed effects. As such, the coefficient on *Confident* is capturing the effect when a confident CEO replaces a cautious CEO, and vice versa. This specification provides the similar inference as in Table 4 on CEO turnover but in a more succinct and transparent way, and it may be less subject to estimation error with propensity-score matching. We find similar results that confident CEO firms are associated with less unreported R&D.

5.5. Heckman Selection and Inverse Probability Weighting Models

Unobservable factors could influence both the confident CEOs' R&D investment decisions and their R&D disclosure choices. Consequently, we repeat our analysis using several other common approaches to missing data. Specifically, we repeat our Table 6 analysis using a Heckman selection model and inverse probability weighting. Untabulated results show that after controlling for possible self-selection using a Heckman model, a confident CEO remains positively related to R&D expenditure in the high disclosure bias period, while no significant relation is documented in the low reporting bias period (z-statistics = 1.93 and −0.51, respectively). These findings are similar to those reported in Table 6. Using an inverse probability weighting model, the results indicate that CEO confidence is positively (negatively) related to R&D in the high (low) disclosure bias period ($|z$-statistics$| > 4.00$). These latter findings offer stronger statistics inferences than those reported in Table 6.

We also apply a Heckman selection model and inverse probability weighting to the analysis reported in Table 8 and obtain inferences similar to our main findings. Specifically, untabulated results indicate that after controlling for potential self-selection, CEO confidence is unrelated to patent/citations in the high disclosure bias period (z-statistics < 1.27) and is negatively related to patent/citations ($|z$-statistics$| > 2.06$). In addition, we find that the incremental effect of CEO confidence on citations is positive (negative) as R&D stock increases in the high (low) disclosure bias period ($|z$-statistics$| > 1.81$). Using an inverse probability weighting model, CEO confidence is unrelated to patent/citations in the high disclosure bias period (z-statistics < 1.16) and is negatively related to patent/citations in the low reporting bias period ($|z$-statistics$| > 2.17$). Finally, the incremental effect of CEO confidence on citations is positive (negative) as R&D stock increases in the high (low) disclosure bias period ($|z$-statistics$| > 1.90$).

Overall, the above analysis suggests that our main inferences are robust to using different approaches to handle the missing R&D data problem.

5.6. 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 Internet Appendix E, 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 ($|z$-statistics$| < 0.92$). Furthermore, we observe no incremental effect of CFO confidence between states that adopt IDD versus states that do not ($|z$-statistics$| < 0.89$).[20] Collectively, our evidence suggests R&D disclosure decisions are more affected by CEOs' traits than CFOs' traits.

5.7. Variation in Enforcement on Financial Reporting and Industry Innovativeness

We also investigate whether our results are driven by variations in government agency oversight or enforcement attention from the SEC and Department of Justice (DOJ) (Reeb et al. 2014). 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 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., PricewaterhouseCoopers, Ernst & Young, Deloitte, and KPMG). Furthermore, 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.[21] Our results are robust to these additional factors that proxy for regulatory enforcement variations across firms.

In addition, we investigate whether our findings in Table 8 are driven by variations in industry innovativeness. We classify innovative industries as in Hirshleifer et al. (2012).[22] We repeat our Table 8 analysis for both innovative and noninnovative industries, obtaining similar inferences to the main results. These suggest our findings are not influenced by differences in the level of innovativeness across industries.

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, involves 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 not report R&D (Lerner and Seru 2015). Consequently, a significant number of firms fail to report any R&D spending even though they regularly seek patents (Koh and Reeb 2015). R&D disclosures provide an ideal test environment for investigating the role of financial disclosure mandates in reducing nondisclosure.

We find that confident CEOs, relative to cautious CEOs, are less likely to hide their R&D expenditures by being an unreported R&D firm (i.e., missing R&D while seeking patents). Exploiting staggered state-level regulatory shocks, changes in CEO type, and an exogenous deviation in regulatory regime, we document that cautious CEO firms significantly underreport their corporate R&D. Taking into account temporal differences in the prevalence of unreported 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 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 nondisclosure problems systematically vary across manager-firm type. If financial disclosure rules are aimed at solving agency induced nondisclosures, then our findings suggest that this solution appears ineffective. Second, the results suggest that cautious CEOs engage in more corporate R&D relative to their more confident counterparts in periods with a lower incidence of R&D opacity. One plausible interpretation is that confident CEOs tend to engage in lower or similar levels of innovation activity but are more forthcoming about such 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.

Acknowledgments

The authors appreciate comments and suggestions from Sumit Agarwal, Craig Brown, Don Chance, Omrane Guedhami, Mark Humphery-Jenner, Ron Masulis, Randall Morck, Ram Mudambi, Wenlan Qian, Amit Seru (the department editor), Vijay Singal, Wei-ling Song, Johan Sulaeman, and two anonymous referees, as well as seminar participants at the ESSEC Business School, Hong Kong University of Science & Technology, National University of Singapore, Southern Illinois University, Temple University, and University of Auckland.

Appendix. Variable Definitions

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

Missing R&D: a dummy variable indicating a firm with blank R&D reporting.

Unreported R&D: a dummy variable indicating a firm with blank R&D reporting while having patents.

Confi-Confi: a dummy variable indicating a new confident CEO replacing an old confident CEO.

Confi-Cautious: a dummy variable indicating a new cautious CEO replacing an old confident CEO.

Cautious-Confi: a dummy variable indicating a new confident CEO replacing an old cautious CEO.

Cautious-Cautious: a dummy variable indicating a new cautious CEO replacing an old cautious CEO.

Firm Size: log of sales.

PPE/EMP: Net property, plant, and equipment per employee in thousands of 2006 dollars.

CEO Age: CEO age in years.

CEO Gender: a dummy variable indicating whether the CEO is female.

CEO Tenure: log of (1 + CEO tenure in months).

Industry Average R&D: the average R&D of each two-digit SIC industry-year.

R&D Stock: cumulative R&D investment over prior 10 years assuming an annual depreciation rate of 15% as in Hall (1990).

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.

CEO Delta: measures CEO wealth change in thousands of 2006 dollars to a 1% change in stock price.

CEO Vega: measures CEO wealth change in thousands of 2006 dollars to a 1% change in annualized standard deviation of stock return.

Industry Competition: Herfindahl index based on sales at two-digit SIC level.

Stock Return: buy-and-hold return of common stock during the previous three years.

Longholder: a dummy variable equal to 1 if the CEO is confident and 0 otherwise (Malmendier et al. 2011). During the CEO's tenure at the firm, if the CEO holds an option until the year of expiration that 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 equal to 1 if the CEO is a net equity buyer in three or more years during the first five years

being CEO and 0 otherwise (Malmendier and Tate 2005). We drop the first five years of CEO tenure in regression analysis.

IDD: a dummy variable equal to 1 when indicating firms in the state that adopt IDD and equal to 0 otherwise.

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

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

Predisclosure/High Bias: a dummy variable indicating the period prior to 2000.

Postdisclosure/Low Bias: a dummy variable indicating the period after 2002.

Endnotes

[1] Conceptually speaking, these represent more and less confident CEOs. We adopt the labels "confident" and "cautious" for this managerial trait; others label these as "overconfident" and "non-overconfident."

[2] We label firms with missing R&D and positive patent activity as "unreported R&D," while the accounting literature denotes these as pseudo-blank R&D firms (Koh and Reeb 2015).

[3] We find similar results using patent approvals. To ensure that patent ownership transfers do not drive our findings (see the discussion of the secondary market for patents in Galasso et al. 2013), we perform additional tests where we exclude patents that in the future experience an ownership transfer (via sale or acquisition).

[4] We also investigate whether failing to report R&D helps to protect a manager's career prospects. We find that CEOs who choose to not report R&D are less likely to lose their jobs after exogenous industry competition shocks than their R&D-reporting CEO peers ($|z\text{-statistics}| \geq 2.28$).

[5] We use the moneyness of exercisable options as our main instrument to categorize a confident CEO (Hirshleifer et al. 2012). Malmendier and Tate (2005) suggest that this measure captures managerial confidence, arguing CEOs do not exercise the options because they overestimate the future success and underestimate the potential risk. In Section 5.2, we discuss the results using alternative measures of managerial confidence—namely, *Longholder* and *Netbuyer*.

[6] The matched sample decreases in size because of this restriction while the results hold if we relax this restriction. We note in Section 5.4 that the main results include firm fixed effects to potentially mitigate some of this concern.

[7] We obtain CEO delta and vega in July 2014 from the personal website of Lalitha Naveen: http://sites.temple.edu/lnaveen/data/.

[8] This is computed as the likelihood of firms with confident CEOs being unreported R&D firms at 9.8% (8.9%) compared with that of cautious CEOs at 12.9% (12%) in the full sample (matched sample) (assuming control variables at sample average). We also perform an additional analysis by including all of the matching dimensions to Equation (1), yielding qualitatively consistent evidence.

[9] We identify states adopting IDD protections using data from Klasa et al. (2017), who also provide detailed descriptions on the nature and characteristics of the IDD protections. We find that no other prominent legislative or regulatory policy changes occur simultaneously in the states with IDD protection change.

[10] 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 firms within the same industry-year combination 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, the number of patents, and past stock return, without replacement using a caliper of 0.1%.

[11] We drop the year of the court decision (year 0) from the sample. Given the sharp drop observed in Figures 2(a) and 2(b), our test design provides a conservative research setting.

[12] An alternative difference-in-differences specification focuses on the effects of CEO confidence before and after IDD adoption among firms that experience IDD shock. The results in panel A of Internet Appendix A suggest a qualitatively similar inference to our findings in Table 3.

[13] Among the 156 CEO turnovers, we identify the following breakdown: 25% cautious to cautious, 28.2% cautious to confident, 21.8% confident to cautious, and 25% confident to confident.

[14] We match confident (cautious) CEO turnover to firms that do not experience CEO turnover. Specifically, we match 61 confident CEO turnovers to 61 no-turnover firms and 91 cautious CEO turnovers to 91 no-turnover firms.

[15] Multiple difference-in-differences tests, using firms without changes in the CEO type as the nontreatment group, indicate that changing from a confident CEO to a cautious CEO leads to a greater incidence of unreported R&D (t-statistics > 2.18). By contrast, changing from a cautious CEO to a confident CEO is associated with a significant decline in unreported R&D (t-statistics > 2.11).

[16] Banerjee et al. (2015) document that after the Sarbanes–Oxley Act (equivalent to our low disclosure bias period) confident CEO firms reduce capital expenditure and pay more dividends. Koh et al. (2016) observe that the missing R&D problem extends beyond the United States, suggesting that this problem is not isolated to the United States.

[17] We choose 0.5% of sales because it is the midpoint between 0 and 1%, a common threshold for auditors in assessing R&D materiality.

[18] We obtain similar results if we replace missing R&D values with zero, 0.5% of sales, single imputation, or multiple imputation.

[19] We find similar results if we use R&D investment instead of R&D stock.

[20] Using an alternative difference-in-differences specification that focuses only on firms operating in states with IDD, we continue to find no evidence that CFO confidence is associated with unreported R&D firms (see Internet Appendix A, panel B; $|z\text{-statistics}| < 0.82$).

[21] We rely on Accounting and Auditing Enforcement Releases and legal actions from the SEC/DOJ, as well as class action lawsuits to capture regulatory attention.

[22] More specifically, two-digit SIC codes 13, 14, 24–27, 29–32, 34–39, 42, 45, 48, 53, 57, 59, 73, 75, 79, 80, 87, and 99 are classified as innovative industries, while the remaining two-digit SIC industries are classified as noninnovative industries.

References

Armstrong C, Larcker D, Ormazabal G, Taylor D (2013) The relation between equity incentives and misreporting: The role of risk-taking incentives. *J. Financial Econom.* 109(2):327–350.

Banerjee S, Humphrey-Jenner M, Nanda V (2015) Restraining overconfident CEOs through improved governance: Evidence from the Sarbanes-Oxley Act. *Rev. Financial Stud.* 28(10):2812–2858.

Ben-David I, Graham J, Harvey C (2013) Managerial miscalibration. *Quart. J. Econom.* 128(4):1547–1584.

Bushee BJ, Matsumoto DA, Miller GS (2004) Managerial and investor responses to disclosure regulation: The case of Reg FD and conference calls. *Accounting Rev.* 79(3):617–643.

Cassiman B, Veugelers R (2006) In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition. *Management Sci.* 52(1):68–82.

Chang H, Chen J, Liao W, Mishra B (2006) CEOs'/CFOs' swearing by the numbers: Does it impact share price of the firm? *Accounting Rev.* 81(1):1–27.

Coffee J (1984) Market failure and the economic case for a mandatory disclosure system. *Virginia Law Rev.* 70(4):717–753.

Coles JL, Daniel ND, Naveen L (2006) Managerial incentives and risk-taking. *J. Financial Econom.* 79(2):431–468.

Easterbrook F, Fischel D (1984) Mandatory disclosure and the protection of investors. *Virginia Law Rev.* 70:669–715.

Ederer F, Manso G (2013) Is pay-for-performance detrimental to innovation? *Management Sci.* 59(7):1496–1513.

Fishman MJ, Hagerty KM (2003) Mandatory versus voluntary disclosure in markets with informed and uninformed customers. *J. Law, Econom. Organ.* 19(1):45–63.

Galasso A, Simcoe T (2011) CEO overconfidence and innovation. *Management Sci.* 57(8):1469–1484.

Galasso A, Schankerman M, Serrano C (2013) Trading and enforcing patent rights. *RAND J. Econom.* 44(2):275–312.

Ge W, Matsumoto D, Zhang J (2011) Do CFOs have style? An empirical investigation of the effect of individual CFOs on accounting practices. *Contemporary Accounting Res.* 28(4):1141–1179.

Goel A, Thakor A (2008) Overconfidence, CEO selection, and corporate governance. *J. Finance* 63(6):2737–2784.

Hall BH (1990) The manufacturing sector master file: 1959–1987. NBER Working Paper 3366, National Bureau of Economic Research, Cambridge, MA.

Hall BH, Jaffe AB, Trajtenberg M (2001) The NBER patent citations data file: Lessons, insights and methodological tool. NBER Working Paper 8498, National Bureau of Economic Research, Cambridge, MA.

Harbaugh R, Maxwell J, Roussillon B (2011) Label confusion: The Groucho effect of uncertain standards. *Management Sci.* 57(9): 1512–1527.

Healy PM, Palepu KG, Ruback RS (1992) Does corporate performance improve after mergers? *J. Financial Econom.* 31(2):135–175.

Hilary G, Hsu C (2011) Endogenous overconfidence in managerial forecasts. *J. Accounting Econom.* 51(3):300–313.

Hirshleifer D, Low A, Teoh SH (2012) Are overconfident CEOs better innovators? *J. Finance* 67(4):1457–1498.

Huang P (2005) Moody investing and the Supreme Court: Rethinking the materiality of information and the reasonableness of investors. *Supreme Court Econom. Rev.* 13:99–131.

Inderst R, Ottaviani M (2012) Competition through commissions and kickbacks. *Amer. Econom. Rev.* 102(2):780–809.

Kedia S, Rajgopal S (2011) Do SEC's enforcement preferences affect corporate misconduct? *J. Accounting Econom.* 51(3): 259–278.

Klasa S, Ortiz-Molina H, Serfling M, Srinivasan S (2017) Protection of trade secrets and capital structure decisions. Working paper, University of Arizona, Tucson.

Koh P-S, Reeb DM (2015) Missing R&D. *J. Accounting Econom.* 60(1):73–94.

Koh P-S, Reeb DM, Sojli E, Tham WW (2016) Measuring innovation around the world. Working paper, National University of Singapore, Singapore.

Kortum S, Lerner J (2000) Assessing the contribution of venture capital to innovation. *RAND J. Econom.* 31(4):674–692.

Lerner J, Seru A (2015) The use and misuse of patent data: Issues for corporate finance and beyond. Working paper, Harvard University, Cambridge, MA.

Lev B, Sougiannis T (1996) The capitalization, amortization, and value-relevance of R&D. *J. Accounting Econom.* 21(1):107–138.

Malecki E (1979) Locational trends in R&D by large US corporations, 1965–1977. *Econom. Geography* 55(4):309–323.

Malmendier U, Tate G (2005) CEO overconfidence and corporate investment. *J. Finance* 60(6):2661–2700.

Malmendier U, Tate G, Yan J (2011) Overconfidence and early-life experiences: The effect of managerial traits on corporate financial policies. *J. Finance* 66(5):1687–1733.

Png I, Samila S (2015) Trade secret laws and mobility: Evidence from "inevitable disclosure." Working paper, National University of Singapore, Singapore.

Reeb D, Zhang Y, Zhao W (2014) Insider trading in supervised industries. *J. Law Econom.* 57(3):529–559.

Scotchmer S (1991) Standing on the shoulders of giants: Cumulative research and the patent law. *J. Econom. Perspect.* 5(1):29–41.

Seru A (2014) Firm boundaries matter: Evidence from conglomerates and R&D activity. *J. Financial Econom.* 111(2):381–405.

Simon C (1989) The effect of the 1933 Securities Act on investor information and the performance of new issues. *Amer. Econom. Rev.* 79(3):295–318.