Accepted Manuscript

Pilot CEOs and Corporate Innovation

Jayanthi Sunder , Shyam V. Sunder , Jingjing Zhang

PII: S0304-405X(16)30197-0
DOI: 10.1016/j.jfineco.2016.11.002
Reference: FINEC 2711

To appear in: *Journal of Financial Economics*

Received date: 10 July 2015
Revised date: 8 January 2016
Accepted date: 22 January 2016

Please cite this article as: Jayanthi Sunder , Shyam V. Sunder , Jingjing Zhang , Pilot CEOs and Corporate Innovation, *Journal of Financial Economics* (2016), doi: 10.1016/j.jfineco.2016.11.002

Pilot CEOs and Corporate Innovation*

Jayanthi Sunder[a]

Shyam V. Sunder[a]

Jingjing Zhang[b,†]

September 2016

Abstract

We find evidence that chief executive officers' (CEOs') hobby of flying airplanes is associated with significantly better innovation outcomes, measured by patents and citations, greater innovation effectiveness, and more diverse and original patents. We rule out alternative explanations, leading us to conclude that CEO pilot credentials capture the personality trait of sensation seeking. Sensation seeking combines risk taking with a desire to pursue novel experiences and has been associated with creativity. Our evidence highlights sensation seeking as a valuable personality trait that can be used to identify CEOs who are likely to drive innovation success.

JEL classification: G32; G34; J24; O31

Keywords: CEOs; Innovation; Personality traits; Sensation seeking; Corporate Governance

* We thank David Yermack (the referee), Bill Schwert (the editor), Steve Fortin, Jiro Kondo, Adolfo de Motta, Zvi Singer, Kelly Wentland (the discussant), seminar participants at Arizona State University, Concordia University, McGill University, Michigan State University, and conference participants at the 2014 Kellogg Accounting Conference at Northwestern University, 2015 Conference on Convergence of Financial and Managerial Accounting Research, and 2015 American Accounting Association Annual Meeting for helpful comments. We also thank Xiao Zhang for excellent research assistance. The authors acknowledge financial support from the Desautels Faculty of Management at McGill University and the Eller College of Management at University of Arizona. All errors are our own.

[a] Eller College of Management, University of Arizona, 1130 E Helen St., Tucson, AZ 85721, United States

[b] Desautels Faculty of Management, McGill University, 1001 Sherbrooke West, Montreal, QC H3A 1G5, Canada

† Corresponding author. Tel.: +1 514 398-8163; Fax: 1 514 398 2499. Email:jingjing.zhang@mcgill.ca

1. Introduction

Innovation is risky, unpredictable, long-term, multi-stage, labor intensive, and idiosyncratic, posing serious challenges to the design of incentive contracts (Holmstrom, 1989). Manso (2011) argues that standard pay-for-performance schemes can be detrimental to innovation. Hellmann and Thiele (2011) also note that optimal incentives for standard tasks do not foster unplanned innovation. Further, through laboratory and field experiments, Glucksberg (1962), Ariely et al. (2009), and Ederer and Manso (2013) show that performance-contingent financial incentives inhibit creativity. Collectively, these studies highlight the limitations of conventional incentive schemes in motivating innovation. In this study, we examine the role of CEO personality traits on innovation and shed light on the effectiveness of using intrinsic rather than extrinsic motivation to encourage innovation.

Prior literature finds that overconfident CEOs who tend to take risks are positively associated with corporate innovation success (Galasso and Simcoe, 2011; Hirshleifer, Low, and Teoh, 2012). While risk taking is a necessary condition for innovation, it may not be sufficient. Studies in psychology have identified that openness to experience, one of the big five factors that define personality, is fundamental to creativity and innovation (Feist, 1998).[1] This insight is confirmed in a recent survey of 5,000 executives by Dyer, Gregersen, and Christensen (2011), who find that successful innovators are "constantly trying out new experiences and piloting new ideas." Our study shows that CEOs who combine risk tolerance with a desire for new experiences achieve greater innovation success. We use CEOs' revealed preference for flying small aircraft as a hobby to capture their innate desire for novel experiences that entail risk and find that pilot CEOs are associated with more successful and original innovation.

[1] The other four factors are conscientiousness, extraversion, agreeableness, and neuroticism.

In the psychology literature, the desire to fly an airplane has been identified as one of the most important factors for predicting the thrill and adventure-seeking component of sensation seeking (Zuckerman, 1971; Zuckerman, Eysenck, and Eysenck, 1978). Sensation seeking is a personality construct, defined as "the seeking of varied, novel, complex and intense sensations and experiences, and the willingness to take physical, social, legal, and financial risk for the sake of such experience" (Zuckerman, 1994, p. 27). More recently, Cain and McKeon (2016) employ pilot certification to proxy for CEO personal risk-taking. However, sensation seekers differ from pure risk takers because their willingness to tolerate risk stems from their desire to seek novel ideas and experiences (Zuckerman, 2007). Sensation seeking has been shown to be positively correlated with openness to experience (Roberti, 2004), and a number of studies find that sensation seekers are receptive to new ideas (e.g., Kish and Donnenwerth, 1969; Mittelstaedt et al., 1976; Lopez-Bonilla and Lopez-Bonilla, 2012). Based on the research on sensation seeking, we expect that pilot CEOs are curious, creative, and open to new ideas, possessing the intrinsic motivation to pursue innovation.[2]

We hand collect CEOs' pilot credentials using the airmen certificate records from the Federal Aviation Administration (FAA). CEOs' willingness to fly is unlikely to be affected by firm conditions because their decision to operate small aircraft as a hobby is made as a personal lifestyle choice. Thus, endogeneity is less of a concern in our study when using CEOs' pilot certification as a measure of their personality trait to explain corporate behaviors. Our sample

[2] Anecdotal evidence suggests a link between the CEO's decision to fly planes and corporate innovation. Micron Technology Inc. is a highly innovative technology firm that manufactures advanced semiconductor products. Steven Appleton, the former CEO of Micron, was actively engaged in flying, among other risky sports. He died in 2012 when his plane crashed during takeoff (see "Executive no-fly zone? Boards grapple with CEOs that fly own planes; Balancing 'freedoms'," *Wall Street Journal*, March 14, 2012).

covers U.S. firms in innovative industries from 1993 to 2003.[3] During the sample period, we identify 88 pilot CEOs and 1,123 non-pilot CEOs. Our primary measures of innovation success are the number of patent applications filed during the year and the number of citations subsequently received by the patents applied during the year. Patent count and citation count are widely used proxies for quantity and quality of innovation outcomes, respectively, in other studies including Hirshleifer et al. (2012), Atanassov (2013), and Seru (2014).

We find that CEOs' hobby of flying small aircraft has a systematic relation with innovation activities in their firms. Firms led by pilot CEOs generate greater innovation outcomes, measured by patents and associated citations. The magnitude of the effect is statistically significant and economically large. In our regressions, we control for firm characteristics, year and industry fixed effects, and CEO characteristics, including age, human capital proxied by CEO tenure and academic achievement, explicit risk-taking incentives, military experience, and overconfidence. Our results are robust to additional controls and alternative subsamples, specifications, and measures of innovation.

We conjecture that pilot CEOs are successful at innovation because they are willing to spend more on innovation activities and/or they are more effective at innovation, given their tendency to be more creative and open to new ideas. We find that the coefficient estimate of pilot CEOs on research and development (R&D) spending is positive and large, but it is not statistically significant, suggesting significant variation in firm R&D input among pilot CEOs. However, controlling for the level of innovation input (R&D spending), pilot CEOs are associated with greater innovation success. The results imply that pilot CEOs achieve success through innovation effectiveness. In contrast, CEOs with higher explicit risk incentives, proxied

[3] We end our sample period in 2003 in order to measure subsequent citations of patents through 2006. We discuss the sample period in detail in Section 3.

by vega of their stock options, invest more in R&D. But once we account for R&D spending, higher vega does not incrementally translate to better innovation outcomes.

Further, to the extent that pilot credentials capture the CEO's openness to new ideas and experiences, we conjecture that patents generated by pilot CEOs span diverse technology fields compared to non-pilot CEOs. Consistent with this prediction, we find that firms with pilot CEOs pursue more diverse and original innovation projects and their patents generate higher market reactions around the patent grant date. These results are even stronger in a subsample of innovative firms, where firms incur positive R&D expenditure during the sample period. At the same time, vega is not associated with originality, or market reactions of the patents and is only weakly related to diversity. The contrasting results between pilot CEOs and vega support the idea that the personality trait proxied by pilot credentials goes beyond risk taking. Overall, the results suggest that, while extrinsic motivation from compensation contracts can result in higher innovation spending, intrinsic motivation of pilot CEOs can be more effective in generating valuable and original innovation.

Common to studies examining CEO characteristics, there are two distinct but related interpretations of our results, i.e., imprinting and matching. Pilot CEOs are able to exert direct influence on the firm's innovation activities. Alternatively, firms that value innovation may choose to hire pilot CEOs who possess desirable personality traits. Matching is not inconsistent with imprinting because firms may appoint pilot CEOs with the expectation that they are able to drive corporate innovation. We examine changes in the patent and citation counts around CEO turnovers and find that, keeping the firm constant, pilot CEOs are associated with higher patent and citation counts. Moreover, the influence of the new CEO on innovation outcomes is increasing over the first three years following the turnover, suggesting that CEO imprinting is an important explanation for our results. We also examine and rule out other alternative explanations for our results.

Our paper makes contributions to two strands of literature. First, the literature in economics and finance focuses almost exclusively on incentivizing effort through contingent rewards (e.g., Gibbons, 1998). But, there is a growing recognition of the importance of intrinsic motivation (Benabou and Tirole, 2003; Hart, 2010). Our results underscore the importance of intrinsic motivation in creative tasks such as innovation. We find that intrinsic motivation is associated with more original, diverse, and valuable patents compared to contractual risk incentives. Further, by contrasting the effects of sensation seeking with risk taking, we show that in the case of innovation, risk taking alone is not sufficient to achieve the best innovation outcomes. To the extent that intrinsic motivation cannot be induced through contracts, the sensation seeking trait can be used by boards to identify CEOs likely to succeed in innovation activity.

Second, our paper is related to studies that examine the effect of personal characteristics on firms' decisions (e.g., Malmendier and Nagel, 2011; Malmendier, Tate, and Yan, 2011; Cronqvist, Makhija, and Yonker, 2012; Graham, Harvey, and Puri, 2013; Davidson, Dey, and Smith, 2015). We add to this literature by showing that sensation seeking, proxied by pilot credentials, leads to more impactful innovation.

The remainder of the paper is organized as follows. Section 2 discusses the construct of sensation seeking as well as its measurement. Section 3 describes sample construction and reports summary statistics. Section 4 presents our empirical results. Section 5 considers alternative explanations. Section 6 concludes.

2. Sensation seeking and pilot CEO

Sensation seeking is a personality construct in psychology that characterizes variation in optimal levels of stimulation and arousal among individuals. Sensation seekers prefer activities that increase the amount of stimulation they experience. The most salient aspect of sensation seeking is the dimension of thrill and adventure seeking that reflects a desire to engage in outdoor sports or recreational activities involving speed, danger, novelty, and defiance of gravity (Zuckerman, 1971).

Existing studies have shown that sensation seekers are more likely to be innovative in their personal life, since they are curious and open to new experiences, prefer changes, and dislike structured and repetitive situations. Mittelstaedt et al. (1976) find that sensation seekers are more likely to be innovative consumers in trying new products and new retail facilities. The results support their hypothesis that sensation seekers differ in their new product adoption decision processes. Sensation seekers "would be more aware of new alternatives, consider more alternatives and, rejecting fewer on the basis of cognitive evaluation alone, would try and ultimately adopt more innovations (p. 92)." Similarly, Lopez-Bonilla and Lopez-Bonilla (2012) provide evidence that sensation seekers are early adopters of new information technologies. Kish and Donnenwerth (1969) also document that sensation seekers prefer vocations with changing and stimulating occupational demands and requiring a problem-solving approach.

In this study, we expect a positive relation between CEO sensation seeking and innovation activities in the firms they manage. Our tests should be viewed as joint tests of whether sensation seeking in these CEOs' personal lives extends to the corporate domain and whether the trait affects corporate innovation output.

Grinblatt and Keloharju (2009) use speeding tickets to identify sensation seekers and find that individuals who speed while driving trade more in their personal stock portfolios. In a similar spirit, we proxy for managerial sensation seeking based on CEOs' revealed preference for flying. Surveys by Zuckerman (1971) and Zuckerman et al. (1978) identify the desire to fly as one of the highest predictors of thrill and adventure seeking.[4] Cain and McKeon (2016) use CEOs' pilot certification to capture risk taking. They show that personal flying is linked to high fatality rate and list examples of CEOs who lost their lives operating small aircraft. While Cain and McKeon (2016) interpret flying as a proxy for risk taking, they acknowledge that it is sensation seeking that endows pilot CEOs with higher tolerance for risks.[5]

We obtain pilot information from the FAA online airmen inquiry website.[6] In the United States, a pilot is required to obtain a pilot certificate regulated by the FAA. The FAA releases the name, certificate level, and rating information for all pilots. Pilot licenses can be searched according to name, date of birth, and/or address. While CEO names are easy to get, using name

[4] It is important to note that sensation seeking is more than just thrill and adventure seeking. It is a constellation of personality traits that also encompass disinhibition and boredom susceptibility. Our measure using pilot certification is not designed to capture these other aspects of sensation seeking.

[5] Despite the fact that sensation seekers are prone to take risks, risk is not the pivotal point of the trait. It is the novelty and intensity of experiences, rather than the risk, which attracts sensation seekers (Zuckerman, 2007). For example, Heyman and Rose (1980) examine students enrolled in a scuba class and find that the sensation seeking score is correlated positively with the length of the time in the first free dive and negatively with the depth of the dive. The authors suggest that sensation seekers may prefer to spend more time exploring the underwater world, but they are less interested in going down deeper when poor visibility compromises their novel experience even though it is riskier. The findings of the study underscore that sensation seekers do not take risk for its own sake, but need the sensation reward to justify the risk.

[6] The website is https://amsrvs.registry.faa.gov/airmeninquiry/. The FAA website also provides a downloadable version of the database. However, the downloadable database does not contain certificate information of those pilots who elected to withhold their personal information. We use the online inquiry instead to mitigate any potential selection bias associated with the downloadable database and to increase the sample size.

alone is not sufficient to identify a person since it is common for people to have the same name. We use the CEOs' date of birth in addition to his or her name to identify pilots. We prefer the date of birth to address because a CEO's address can change over time.

We start with CEO names from ExecuComp, which provides information on the top paid executives of Standard & Poor's (S&P) 1500 firms. Because ExecuComp coverage begins in 1992, to alleviate any potential survival bias, we restrict our sample to the CEOs whose "Became CEO" dates in ExecuComp are on or after January 1, 1991. We then conduct a name search using the first name, middle initial, and last name on the FAA's online airmen inquiry website. If the name is found, we rely on date of birth (in some cases, we use only month and year of birth when the exact birth date is unavailable) to ensure accuracy of the match. We collect CEOs' date of birth from various sources such as Bloomberg, BoardEx, Lexis, the Notable Names Database (NNDB), and Westlaw. After entering the date of birth, if the match remains valid, we classify this CEO as a pilot. If a CEO's name is not matched or if a CEO's date of birth is not matched following a name match, we classify this CEO as a non-pilot.[7] At the end, we are able to identify pilot and non-pilot CEOs for 88.7% of the initial CEO list from ExecuComp.

3. Sample construction and summary statistics

This section describes the sample, defines the dependent variables and the control variables, and provides summary statistics. A detailed description of variable definitions is provided in the Appendix.

[7] We discard observations when the CEO's desire to fly as a hobby is unclear or there is inadequate information for a match. These include (i) CEOs with non-airman certificate issued by the FAA, (ii) CEOs who have served as pilots in military but for whom we cannot find an airmen certification record, and (iii) cases in which a CEO's name is matched, but we are unable to obtain his or her date of birth for further verification.

3.1. Sample construction

We construct our sample from several different sources. We start with the list of CEOs from the ExecuComp database, which provides name, title, and compensation related information for the top paid executives of S&P 1500 firms. We then hand collect data to identify pilot and non-pilot CEOs based on airmen certificate records. Restricting the sample to firm-years with CEOs who can be classified as pilots or non-pilots, we obtain accounting variables from Compustat, stock returns from the Center for Research on Security Prices (CRSP), and patent data compiled by the National Bureau of Economic Research (NBER), which covers patents awarded through 2006.

Our sample consists of firms operating in the four-digit Standard Industrial Classification (SIC) industries where the average patent count per firm in the industry is at least one. Such a requirement allows us to include firms with zero patents while excluding firms where innovation is less likely to be important. In some analyses, we further restrict our sample to innovative firms based on whether they incur R&D expenditures during the sample period. Firm-years with missing values on explanatory variables are deleted. We exclude financial firms and regulated utilities. We also remove firms in the aviation industry to address the concern that firms in this industry are more likely to hire CEOs with flying experience. The resulting sample includes 88 pilot CEOs and 1,123 non-pilot CEOs, covering 4,494 firm-years between 1993 and 2003.[8]

[8] A relatively high proportion of pilots among CEOs could be attributed to two factors: CEOs are more likely to be sensation seekers resulting in a desire to fly, and/or significant wealth allows CEOs to express their sensation seeking through the venue of flying (see "Executive no-fly zone? Boards grapple with CEOs that fly own planes; Balancing 'freedoms'," *Wall Street Journal*, March 14, 2012).

3.2. Variable measurement

3.2.1. Measuring innovation

We construct our main innovation variables from the NBER patent database. This database provides annual information on patent assignee names, the number of patents, the citations made or received by each patent, the application year, and the grant date, among other items. The latest version of the NBER database covers all patents awarded by the United States Patent and Trademark Office (USPTO) from 1976 to 2006. We date our patent data according to the application year rather than the grant year because prior studies have shown that the application is closer to the actual timing of innovation (Griliches, Pakes, and Hall, 1987). Even though we use the application year as the relevant year to match the data, the database only covers patents that have been awarded. Thus, we in fact analyze patent applications that are eventually granted.

We use two metrics that describe a firm's patenting activity to proxy for the firm's innovation outcomes. The first metric is a simple count of the number of patent applications that are filed for each firm-year. This metric is straightforward to construct, but it falls short of capturing variations in a patent's technological and economic importance. Our second metric is the number of citations subsequently received by the patents applied for in a given year. If a patent is cited later on, it implies that the patented technology is valuable for subsequent innovation endeavors. Therefore, citation count captures the quality of innovation. Moreover, the total citation count is affected by both the number of patents and the number of citations per patent. Hence, the metric of citation count is a more comprehensive measure of a firm's innovation outcome than patent count alone.

Patent data are subject to two types of truncation problems. The first type of truncation problem arises because there is, on average, a two-year lag between a patent's application date and grant date. Since patents are included in the database only if they are granted, we are unable to observe the patents that were applied for but were still under review by 2006, the last year in the patent database. This truncation problem affects the metric of patent count. To address this truncation problem, we follow Hall, Jaffe, and Trajtenberg's (2001) suggestion to end our sample period in 2003.[9] The second type of truncation problem affects the metric of citation count. Citations are accumulated over a long period of time. But we can only observe the citations received up to 2006. To correct for this truncation bias, we multiply the raw citation count by the weighting index provided in the NBER patent database. This weighting index is constructed using a quasi-structural approach in which the shape of the citation-lag distribution is econometrically estimated (Hall et al., 2001, 2005). In the regressions, we also include year fixed effects to absorb any aggregate time effects that exist in the data.

There is a limitation to using patent data. Not all innovation outcomes are patented (Hall et al., 2001). First, some inventions do not meet the patentability criteria set by the USPTO. Second, the inventor can rely on secrecy or other means instead of patents to protect the invention. Despite these limitations, as Griliches (1990) notes, there is no other widely available measure to better capture firms' technological advances. In the analyses, we include industry fixed effects to control for heterogeneity in the use of patents.

3.2.2. Control variables

Following the innovation literature, we control for a vector of time-varying firm characteristics that are important determinants of innovation activities. Our firm controls include firm size (the natural logarithm of assets), capital intensity (the natural logarithm of the ratio of net property, plant, and equipment to the number of employees), stock performance (the buy and

[9] The sample period refers to the period we collect our independent variables. Since we lag our independent variables by one year, we actually use the patent data for our dependent variables from 1994 to 2004.

hold stock return over the fiscal year), Tobin's *Q* (the natural logarithm of market value of assets over the book value of assets), and institutional holdings (percentage of shares held by financial institutions).

In the regressions, we also control for CEO-specific variables that capture their age, human capital, extrinsic incentives, and other behavioral traits. We measure human capital and experience using CEO tenure, defined as the number of months a CEO is in office. Additionally, academic achievement is an important dimension of CEO human capital and we proxy for this with several variables that measure the quality of educational institution and the field of study. First, we identify CEOs who attended a top university based on whether the CEO's undergraduate institution is in the top 50 schools ranked by *U.S. News & World Report* in any year during the period 1983 through 2007. For the field of study, we follow Malmendier and Tate (2008) and Galasso and Simcoe (2011) to identify CEOs with finance or technical education. CEOs with finance education received undergraduate or graduate degrees in accounting, finance, business (including MBA), or economics. CEOs with technical education received undergraduate or graduate degrees in engineering, physics, operations research, chemistry, mathematics, biology, pharmacy, or other applied sciences. In addition, to control for CEOs' expertise in the fields that are particularly relevant for innovation, we create a separate indicator variable for CEOs who hold PhDs in engineering, technology, and science.[10]

We use the delta and vega of a CEO's stock and option portfolio to proxy for a CEO's incentive for risk taking induced by their compensation contracts. Delta is defined as the dollar change in a CEO's stock and option portfolio for a 1% change in stock price, and vega is the

[10] Our results are robust to using Ivy League as an alternative way to define top schools, adding a dummy variable indicating the CEO received undergraduate education in a foreign school, employing a finer classification to characterize majors, and separating the fields by undergraduate and graduate studies.

dollar change in a CEO's option holdings for a 1% change in stock return volatility. These two measures are calculated using the one-year approximation method proposed by Core and Guay (2002). Finally, we control for other related behavioral traits that might influence the CEO's willingness to engage in R&D activities. Malmendier et al. (2011) find that CEOs' military service during early adulthood can induce risk-taking behaviors in the firms they lead, and Benmelech and Frydman (2015) show a negative relation between military CEOs and R&D expenditures. We thus control for CEOs' military background. Last, Galasso and Simcoe (2011) and Hirshleifer et al. (2012) provide evidence suggesting that overconfident CEOs are better innovators. Following Malmendier and Tate (2005) and Hirshleifer et al. (2012), we measure CEO overconfidence based on the CEO's option-exercise behavior. We classify CEOs as overconfident if they overexpose themselves to firms' idiosyncratic risk. To operationalize this idea, we classify a CEO as overconfident if he or she chooses to hold vested options that are at least 67% in the money.[11]

All control variables are lagged by one year. For ease of comparison, we standardize all the continuous control variables to have a mean of zero and a standard deviation of one. As noted earlier, we also include year and industry fixed effects in the regressions to account for systematic variations in dependent variables across year and industry, defined at the two-digit SIC level.

3.3. Summary statistics

Table 1 reports descriptive statistics on the pilot certificates for CEOs who have the certificate records at the FAA. Panel A lists the number of pilot certificates held by CEOs in our sample in the ascending order of privileges. Among 88 pilot CEOs we identified in the final

[11] We obtain similar results if we classify a CEO as overconfident when the CEO holds vested options that are at least 100% in the money.

sample, seven pilot CEOs hold student certificates. This is the lowest level that a pilot can get. At this level, the certificate authorizes limited solo flight for specific types of aircraft. More than two-thirds of pilot CEOs possess private pilot certificates. At this level, pilots are able to command a potentially wide range of aircraft for non-commercial purposes. About one-quarter of the pilot CEOs reach higher levels, getting commercial or even airline transport pilot certificates. These two levels of certificates allow pilots to operate more complex airplanes and fly for compensation. But obtaining commercial or airline transport pilot certificates does not necessarily mean the holders intend to become professional pilots. Pilots can obtain higher levels of certificates to reduce insurance premiums as higher levels of certificates are evidence of more experience (Cain and McKeon, 2016).

At each certificate level higher than student certificate, pilots are also rated on categories of aircraft they operate. Panel B shows a variety of ratings held by pilot CEOs in our sample. While the majority of pilot CEOs have the rating to fly single engine airplanes (79), some obtain the ratings to allow them to operate more powerful multiengine airplanes (23), helicopters (6), gliders (1), or aircrafts that land on sea (6). Moreover, half of the pilot CEOs do not have an instrument rating. These pilot CEOs are not allowed to fly long distances that are usually required for business travel (Cain and McKeon, 2016).

Table 2 presents the distribution of pilot CEOs across years and industries. Panel A tabulates the frequency of pilot CEOs by year. The percentage of pilot CEOs fluctuates within a tight range from about 6% in 1994 to around 9% in 2000. On average, pilot CEOs comprise close to 8% of the observations. Panel B displays the distribution of pilot CEOs by the 12 Fama and French industries, excluding firms in finance and utilities industries. Business equipment constitutes close to one-third of the overall sample. Energy has the highest percentage of pilot CEOs (22.61%), followed by other (10.00%), and business equipment (9.68%).[12]

Table 3 reports descriptive statistics for the major variables used in this study. We classify the sample based on the CEO's pilot credentials and report the means, medians, and standard deviations of those variables. We also perform *t*-tests and Wilcoxon-Mann-Whitney tests to compare the sample means and medians between the groups with and without pilot CEOs. As expected, we find that firms led by pilot CEOs tend to have higher innovation outcomes measured by both patent count and citation count than firms led by non-pilot CEOs. For example, a firm with a pilot CEO, on average, has about 33 (73%) more patent counts and 639 (104%) more citation counts per year than a firm with a non-pilot CEO. The differences between the two groups are statistically significant. Moreover, in univariate tests, we find that firms with pilot CEOs also tend to spend more on R&D. We do not find statistically significant differences on the average scores of diversity and originality between firms with and without pilot CEOs.

With regard to other variables, when comparing sample means of the variables representing firm characteristics, we note that firms led by pilot CEOs have greater capital intensity. For the remaining firm-specific control variables, there is no significant difference between the two groups, which mitigates the concern that our results are driven by differences between firms led by pilot CEO and other firms. However, we do find significant differences in extrinsic incentives and personal characteristics between pilot and non-pilot CEOs. Pilot CEOs tend to have higher vega values in their compensation packages. They are also younger, more likely to hold a PhD in technical education, and have military experience. Surprisingly, pilot

[12] The fact that there is a high proportion of pilot CEOs in the energy industry could be due to industry-specific factors such as geographical remoteness of oil fields. In a robustness check, we exclude firm-years belonging to the energy industry to ensure that our results are not driven by this specific industry.

CEOs are less likely to have graduated from a top school. To the extent that the quality of schools reflects the intellectual capacity of students, we do not find evidence in the univariate tests suggesting that pilot CEOs are more intelligent than other CEOs.

4. Empirical results

In this section, we examine whether and how pilot CEOs spur corporate innovation.

4.1. Patenting activities

Table 4 presents the results on the relation between *Pilot CEO* and innovation outcomes measured by patent and citation counts, estimated using both Poisson and ordinary least squares (OLS) models. Following Hausman, Hall, and Griliches (1984), columns 1 and 2 report the estimates from a Poisson model with patent count and citation count as the dependent variables, respectively. Hausman et al. (1984) used data from Pakes and Griliches (1980) that imposed minimum R&D requirements and thus mitigated the problem of excessive firm-years with zero patent counts. Our primary sample does not impose such a restriction and therefore we observe frequent zero patent and citation counts to the tune of 35.8% and 46.5%, respectively. We address this issue by reporting estimates from a zero-inflated Poisson model in columns 3 and 4. To predict zero patents or citations, we rely on the reported R&D value. If a firm does not report any positive R&D expenditure during the sample period, the firm is unlikely to be engaged in innovation and, thus, more likely to have zero patents or citations. Finally, columns 5 and 6 report the OLS estimates for comparability of our results with some recent papers that use OLS (e.g., Hirshleifer et al., 2012; He and Tian, 2013), where the dependent variables are the natural logarithm of one plus patent or citation count. We add one before taking the log transformation so that we can keep firm-years with zero patents or citations. In all the regressions, we include year and industry fixed effects. Standard errors are clustered at the firm level to account for within-firm correlations.

Across all the columns of Table 4, the estimated coefficients on *Pilot CEO* are positive and significant at the 1% to 5% level, supporting our hypothesis that firms managed by pilot CEOs are associated with greater innovation success. The magnitude of the coefficients ranges from 0.334 to 0.583 for patent counts and lies between 0.364 and 0.618 for citation counts. A coefficient of 0.511 in column 3, estimated using a zero-inflated Poisson model, implies that a pilot CEO in the firm increases the number of patents by 66.7% (computed as $e^{0.511} - 1$). Similarly, according to column 4, having a pilot CEO increases the number of citations for all the patents applied for in a given year by 43.9% (computed as $e^{0.364} - 1$). To the extent that *Pilot CEO* captures sensation seeking, it reflects a sizable influence of CEO personality trait on innovation success. For comparison, the absolute value of this effect is lower than firm size but higher than all other firm-level variables, including Tobin's *Q*, when changing those firm-level variables by one standard deviation.

Comparing across columns, we note that the results on *Pilot CEO* are similar for both the Poisson estimations, with and without modeling the zero-inflation problem. The coefficients tend to have the same sign and similar significance level. Between these two alternative Poisson models, we prefer the zero-inflated model reported in columns 3 and 4 for the following two reasons. First, in the unreported splitting model, we note that *Positive R&D*, an indicator of positive R&D expenditure in the sample period, significantly predicts the likelihood of zero patents and citations. Second, the Vuong test favors the use of the zero-inflated Poisson over the regular Poisson, and the zero-inflated Poisson predicts a percentage of zeros that is similar to the actual data. Further, formal tests reject the assumption that the residuals in the OLS specification follow a log-normal distribution. In subsequent tests on patent and citation counts, we only report the results estimated from the zero-inflated Poisson model. Nevertheless, the inference we draw on pilot CEOs in Table 4 and other tables is not sensitive to model choice.

With respect to other CEO characteristics, we find some evidence that overconfident CEOs are positively associated with patents and citations in their firms, similar to the findings of prior studies. *CEO age* is generally negative, suggesting that younger CEOs are more successful in innovation. Age could capture two alternative constructs: one is CEO experience that is increasing in age, and the other is sensation seeking, which is decreasing in age. Our results are more consistent with *CEO age* capturing sensation seeking, thus potentially weakening the effect of *Pilot CEO*. While these results on overconfidence and age are not statistically significant in the OLS specification, they hold across all Poisson models. Regarding variables that capture academic achievement, we do not find consistent results when we evaluate each proxy individually. However, since these variables collectively proxy for CEO intellect and academic achievement, we conduct a joint test of *Top university*, *Finance education*, *Technical education*, and *PhD in technical education*. We find these variables are jointly significant at the 5% level. Alternatively, in an unreported test, we construct an education score by adding *Top university*, *Finance education*, *Technical education*, and *PhD in technical education*, and use the score in the regressions instead. The coefficient estimates of this education score are positive and significant in all the Poisson models. Finally, there is no strong evidence suggesting that vega in CEOs' option holdings improves innovation.

4.2. R&D spending

To identify the mechanism through which pilot CEOs contribute to innovation at the firm, we first examine whether they achieve higher levels of patenting activity from higher innovation input. If pilot CEOs have a greater tolerance for risky investments, we expect that they invest more in innovation projects. We use R&D spending to measure input in innovation. It is computed as R&D expenditure scaled by lagged assets and expressed in percentage terms, with missing values set to zero.

Table 5 displays the OLS result from regressing R&D spending on *Pilot CEO*. The estimated coefficient on *Pilot CEO* is positive as expected, with a coefficient that is similar in magnitude (1.138) to that of variables such as *Technical education* (1.524) and *Overconfidence* (1.676). However, the coefficient on *Pilot CEO* is not statistically significant (t = 1.18), suggesting significant variation among pilot CEOs, i.e., not all pilot CEOs enhance innovation performance by spending more on R&D.

Examining the control variables, we find that overconfident CEOs spend more on R&D, consistent with Galasso and Simcoe (2011) and Hirshleifer et al. (2012). Overconfident individuals take risks because they tend to overestimate their own abilities (Malmendier and Tate, 2005). This bias causes overconfident CEOs to invest more heavily in risky innovation projects. In contrast, sensation seeking individuals take risks to fulfill their pursuit of novel experience (Zuckerman, 2007). We therefore expect pilot CEOs to be more selective in choosing among innovation projects based on novelty. However, this is potentially a weak test to distinguish pilot CEOs from other CEOs since R&D spending reflects only the aggregate amount of investment in innovation, not the type of individual innovation projects. We also find a strong positive association between vega and R&D spending, similar to Coles, Daniel, and Naveen (2006). The differential results between *Pilot CEO* and vega indicate that while extrinsic motivation through compensation contract incentivizes managers to invest more in R&D projects, intrinsic motivation to embark on fundamentally breakthrough projects is not necessarily linked with higher R&D spending.

Similar to Table 4, the results on individual proxies for academic achievement are mixed. While we find a positive association between *Technical education* and R&D spending, the coefficients on other education proxies are not statistically significant. The estimated coefficient on *PhD in technical education* (2.916) is economically large, but marginally insignificant at conventional levels (t = 1.58). In unreported tests, the joint effect of *Top university*, *Finance education*, *Technical education*, and *PhD in technical education* on R&D spending is positive and statistically significant.

In untabulated analyses, we scale R&D expenditure by sales instead of assets; we exclude observations with missing reported R&D value; we employ a quantile regression to address the concern that the results are potentially driven by outliers of R&D expenditure in the data. The estimated coefficients on *Pilot CEO* in these analyses continue to be statistically insignificant.

4.3. Innovation effectiveness

Thus far, our results show that firms managed by pilot CEOs are associated with higher patent and citation counts, despite the lack of a statistically significant relation between R&D spending and pilot CEOs. In this section, we examine whether pilot CEOs achieve better innovation outcomes through higher innovation productivity. If intrinsic motivation causes CEOs to be more engaged in innovation activities of the firm, we expect them to be more effective in the innovation process. To test the idea, we add R&D spending to the specification reported in Table 4 to capture the input into innovation activity. Controlling for R&D spending, the coefficient on *Pilot CEO* estimates the innovation effectiveness of pilot CEOs.

The results are reported in Table 6 with column 1 on patent count and column 2 on citation count. The estimated coefficients on *R&D spending* are positive in both columns, with one being marginally insignificant (z = 1.60) and the other statistically significant at the 5% level, confirming that innovation output is increasing in investment in R&D. The estimated coefficients on *Pilot CEO* in both columns remain positive and significant, with economic magnitudes that are even slightly larger than the corresponding coefficients in Table 4. The evidence in this table shows that pilot CEOs are able to generate more patents and citations after controlling for the level of R&D spending, implying greater innovation effectiveness.

4.4. Innovation characteristics

Cain and McKeon (2016) use CEOs' pilot certification to proxy for CEO personal risk taking and find that pilot CEOs are associated with elevated risks in the firms they manage. To provide evidence that our results relate to sensation seeking rather than mere risk taking, we examine the characteristics of patents. In the context of corporate innovation, we argue that the sensation seeking trait makes pilot CEOs more impactful innovators. This is because in addition to a willingness to undertake risk, sensation seekers are also open to new experiences and have the ability to think outside the box. According to Dyer, Gregersen, and Christensen (2009), successful innovators have the "ability to successfully connect seemingly unrelated questions, problems, or ideas from different fields (p. 63)." Accordingly, we expect that firms led by pilot CEOs generate a more diverse and original patent portfolio across technological classes, a prediction that does not follow from pure risk taking.

We use two measures developed in the innovation literature to capture the nature of a firm's innovation activities (Custodio, Ferreira, and Matos, 2015). The first measure is *Diversity*, defined as one minus the Herfindahl index of the patents applied for in a given year by a firm across three-digit technological classes. A higher value of *Diversity* means a lower concentration of the patent portfolio in technological fields. The second measure is *Originality*, defined in a similar way but using the information of backward citations. It is computed as one minus the Herfindahl index of the citations made by the patents applied for in a given year by a firm based on three-digit technological classes. A higher value of *Originality* indicates that the patents cited in the portfolio of patents applied for in a given year by a firm belong to a wider range of technological fields.

Table 7 presents the results. In columns 1 and 3, we find that the estimated coefficients on *Pilot CEO* are both positive. However, the coefficient is not significant in column 1 when the dependent variable is *Diversity*, even though the t-value (1.52) is not far from the critical value, and the coefficient is marginally significant ($t = 1.79$) in column 3 when explaining *Originality*. One potential limitation of this analysis is that it is difficult to evaluate the characteristics of patents when firms occasionally engage in innovation activities. To address this issue, we restrict our sample to innovation firms and report the results in columns 2 and 4. We define innovative firms as firms reporting positive R&D during the sample period. This is similar in spirit to Hausman et al. (1984) imposing minimum R&D requirements in their sample construction. After restricting the sample to innovative firms, we find that, as expected, *Pilot CEO* is positively associated with both *Diversity* ($t = 2.00$) and *Originality* ($t = 2.38$), with larger effects (0.038 vs. 0.029 and 0.037 vs. 0.029, respectively). Overall, the evidence in Table 7 suggests that, in innovative firms, sensation seeking CEOs are more likely to pursue a variety of innovation projects, providing comfort that our findings are not entirely driven by CEO personal risk taking.

4.5. Market reaction

While our results so far have shown that pilot CEOs spur corporate innovation and prior studies demonstrate that innovation is, on average, positively associated with firm value (Hall et al., 2005), the question remains whether shareholders of the firms with pilot CEOs actually benefit incrementally from the innovation outcomes. It is possible that firms led by pilot CEOs generate patents with tremendous societal value measured by subsequent citations but little economic value for shareholders. In this section, we analyze the market's reaction to patent announcements, which provides a more direct measure of value creation for shareholders.

The USPTO publicizes the list of patents that are granted every Tuesday. Kogan et al. (2016) find a positive stock market response to news about patents around the grant dates.

Following their study, we examine whether investors react more favorably to patents applied for by firms with pilot CEOs. Multiple patents that were applied for at different times can be granted on the same day for a given firm. To ensure that all patents were generated under the leadership of one CEO, we require that the same CEO is in place both on the grant date and at least one year before the application date for all the patents approved on a given date *t* for the firm *i*. Therefore, for any firm *i* on a given grant date *t*, all patent grants are associated with only one CEO *j*, making subscript *j* redundant for a given *i*, *t* combination. Specifically, we estimate the following regression:

$$CAR_{i,t} = \beta_0 + \beta_1(Pilot\ CEO)_{i,j} + \beta_2 Log(Number\ of\ patents)_{i,t} + \beta_3(Average\ tenure)_{i,t} + \beta_4(Average\ delta)_{i,t} + \beta_5(Average\ vega)_{i,t} + \beta_6(Average\ CEO\ age)_{i,t} + X'_{i,j}G + \varepsilon_{i,t}, \tag{1}$$

where $CAR_{i.t}$ is the size-adjusted excess return for firm i at time t, which is defined as the three-day window [0, + 2] around the patent-grant date.[13] $(Pilot\ CEO)_{i,j}$ is the CEO j's pilot credentials for firm i. In the regression, we control for the number of patents granted to firm i on the same grant date t. We also include CEO characteristics and incentives that can affect the value of the patents. Since the values of tenure, delta, vega, and CEO age are estimated at the time of patent application, for each of these variables, we compute the average value for the portfolio of patents that were applied for at different times but are granted on day t. $X_{i,j}$ represents the set of time-invariant characteristics of CEO j in firm i, including CEO j's educational background, military experience, and overconfidence.

Table 8 reports the results from estimating Eq. (1). We find that the estimated coefficient on *Pilot CEO* is positive and statistically significant (t = 2.07). Vega and CEO age are the only control variables that are statistically significant at the conventional level and they are negatively

[13] The results are similar if we use market-adjusted returns to compute *CAR*.

associated with market reaction. The results indicate that the patents created by firms with pilot CEOs or younger CEOs generate higher value for shareholders. But the value of the patents is lower for firms with higher vega in the CEO’s compensation. This result underscores the limitation of using compensation contracts to motivate high value innovation.

4.6. Robustness tests

In this section, we conduct a series of tests to ensure that the preceding findings on the positive association between pilot CEOs and patenting activities are robust to alternative measures, additional firm control variables, and various subsamples.

Alternative measures of citation

In the first set of robustness checks, we rerun the regressions using three alternative measures of citation count. One is the number of citations excluding self-citations to address the potential concern that there is a systematic difference among firms based on whether they cite their own patents. In the second measure, we adopt the fixed effects approach to remedy the time truncation problem associated with the citation measure, namely, we scale the raw citation count by the average citation count for patents in the same cohort by technology class and year. The advantage of this approach is that it imposes fewer assumptions on the citation-lag distribution (Hall et al., 2001, 2005). The third measure is the number of citations per patent to ensure that the positive effect of pilot CEOs on citation count is not entirely driven by the result of patent count. Our results are robust to these alternative measures of citation count.

Additional firm controls

Next, we include extra firm-level controls in the regressions. Recent studies on innovation have identified additional determinants of firms’ patenting activities. For example, Aghion et al. (2005) find an inverted-U relationship between product market competition and innovation. He and Tian (2013) identify a negative causal effect of analyst coverage on firm innovation. Fang, Tian, and Tice (2014) show that stock liquidity can impede innovation. Since we measure CEO sensation seeking from CEOs' revealed preference in their private life, it is unlikely that those identified determinants correlate with CEOs' decisions to fly small aircraft. Hence, our results are less subject to the omitted correlated variable problem. Nevertheless, we include several additional firm control variables such as the Herfindahl index for the industry in which the firm operates, calculated based on sales and its squared term, analyst coverage, stock liquidity, sales growth, return on assets (ROA), leverage, and cash holdings in the regressions to explain patenting activities. Despite the fact that the sample size becomes smaller when including additional controls, the results are quantitatively and qualitatively similar.

Alternative subsamples

In the final set of tests, we reexamine our results in several subsamples to ensure that the results are not sensitive to sample selection and research design. First, we identify pilots based on U.S. airmen certificate records. This approach could misclassify CEOs who have equivalent pilot credentials from a foreign country as non-pilots. While it is infeasible for us to seek pilot records and match individuals in other countries, we examine whether the results would change if we remove the cases where misclassification is more likely to happen. We collect the CEOs' country of birth and exclude all foreign-born CEOs in the analysis.[14] After dropping the observations prone to measurement error, we find slightly stronger results in the remaining sample. Second, in our sample construction, we require CEOs to have been appointed on or after 1991 to reduce survival bias. But this requirement can introduce another bias that we tend to exclude older CEOs from the early period of our sample. While we do not expect that this bias varies systematically between pilot and non-pilot CEOs, we control for CEO age in all the

[14] We supplement our hand-collected data with a list of CEOs' country of birth from Bernile, Bhagwat, and Rau (2016). We thank the authors for sharing the data.

regressions. Here, we conduct an additional analysis to exclude older CEOs from the sample. We alternatively drop firm-years where CEO age is equal to or greater than 60 years, which is typically used as the retirement age cut-off, 62 years (the 95th percentile of the age distribution), and 68 years (99th percentile of the age distribution). The results remain similar in each of these subsamples. Third, we restrict the sample to innovative firms, where zero patents are less likely. The results are not sensitive to this sample restriction.

5. Alternative explanations

In this section, we consider several alternative explanations for the positive association between pilot CEOs and corporate innovation outcomes.

5.1. CEO ability

One possible concern about our *Pilot CEO* variable is that it captures CEO ability and firms led by CEOs with higher ability perform better in innovation. In the regressions, we already control for CEOs' educational background, using various measures to define the quality of the CEO's undergraduate institution and the field of study. However, the *Pilot CEO* variable can still pick up certain aspects of CEOs' ability that are not manifested in the educational record. To address this concern, we conduct an indirect test. If pilot CEOs have some superior ability that is unobservable to researchers but known to the board of directors, we should expect that pilot CEOs earn higher compensation. But this is not the case. Cain and McKeon (2016) find that *Pilot CEO* is only significantly related to the structure of compensation, not the amount. Similar to their findings, we find that, in our sample, pilot CEOs prefer compensation with higher vega, but do not get higher total pay. The absence of a relation between *Pilot CEO* and total compensation corroborates the notion that our main results are less likely to be driven by the omitted variable of CEO ability.

5.2. Transportation convenience

CEOs can obtain a pilot license for the convenience of transportation. In this case, pilot certification does not measure sensation seeking. To evaluate this alternative explanation, we examine the location of firm headquarters. We find that 82% of firms with pilot CEOs are located in Metropolitan Statistical Areas (MSA) having an international airport, suggesting that the need for air transportation is not the primary reason for CEOs to pursue flying. Further, 87% of firms with non-pilot CEOs are located in such large MSAs, indicating that access to an international airport is not very different for the two types of CEOs. Furthermore, as presented in Table 1 Panel B, about half of the pilot CEOs in our sample do not have an instrument rating, precluding them from long-distance flying. So, it is unlikely that the documented results can be attributed to the explanation of CEOs seeking transportation convenience.

5.3. Endogenous matching

The previous two alternative explanations question the appropriateness of interpreting pilot certification as a good proxy for sensation seeking. Even if our proxy measures sensation seeking satisfactorily, there are still two possible interpretations of the documented positive relation between pilot CEOs and innovation. One interpretation is endogenous matching of CEOs and firms. Endogenous matching suggests that pilot CEOs tend to be hired by innovative firms that demand this personality trait. The alternative interpretation is based on CEOs' direct influence, i.e., pilot CEOs can imprint their personal preferences on corporate policies and engage in more innovation. These two views are not mutually exclusive. In fact, the matching interpretation is largely compatible with the imprinting interpretation. CEO-firm matching occurs largely because the firm believes that the CEO will imprint his or her personal style on the choice of investments in the firm (Hirshleifer et al., 2012; Benmelech and Frydman, 2015).

To provide evidence on CEO imprinting, we focus on CEO turnovers to examine changes in firms' innovation activities. We compute the change in each variable as the difference between the value measured after the new CEO takes office and the value measured when the previous CEO was in power. Specifically, we calculate the changes in all variables separately for each of the first three years of the new CEO in office (years 1, 2, and 3 relative to turnover) compared to the last year of the predecessor CEO in charge (year -1 relative to turnover).[15] We exclude the turnover year when both the current and previous CEOs are in control for different parts of the year.

Table 9 reports the OLS results from this analysis with the dependent variables capturing the changes in patent and citation counts, respectively. The variable of interest is Δ *Pilot CEO*. The coefficient on this variable reflects the effect of a pilot CEO relative to a non-pilot CEO on innovation for the same firm. From year –1 to year 1, there are 190 CEO turnovers in our sample. The estimated coefficients on Δ *Pilot CEO*, reported in the first two columns, are positive for both patent and citation counts (0.054 and 0.279), but they are not statistically significant. The next two columns present the results from year –1 to year 2. The sample size is reduced to 136. We continue to find the positive coefficients for Δ *Pilot CEO*. This time, the magnitudes of the coefficients are larger (0.559 and 0.695), and they become statistically significant at the 10% level. The sample size shrinks to 83 in the last two columns when we examine the difference between year –1 and year 3, but the results are even stronger. The magnitude of the coefficients becomes larger (0.804 and 1.238) and the coefficients are statistically significant at the 5% level. In unreported analysis, we exclude the likely endogenous firm-level controls in the regression and continue to get similar results.

[15] We stop in year 3 because the sample size becomes very small for any year beyond year 3.

In short, we find that over the first three years following a CEO turnover, the effect of a pilot CEO gets stronger over time, consistent with the new CEO shaping the innovation strategy and culture of the firm. The evidence from the CEO turnover analysis supports the imprinting interpretation that pilot CEOs have an active influence on firm innovation. However, as Fee, Hadlock, and Pierce (2013) point out, most CEO departures are not random, we cannot completely rule out the possibility of endogenous matching between CEOs and firms. Thus, in the absence of exogenous CEO transitions, we should interpret the results from our CEO turnover tests with caution.

6. Conclusion

In this paper, we use CEOs' revealed preference for flying small aircraft as a hobby to proxy for sensation seeking, a personality trait defined as the search for novel and exciting experiences that entail risks. We find that firms led by pilot CEOs generate more patents and patents with greater impact. While risk-taking incentives induced by vega encourage more spending on R&D, pilot CEOs achieve better innovation outcomes by improving innovation effectiveness and pursuing more diverse and original innovative projects. Our results provide new empirical support for the importance of managerial intrinsic motivation on tasks requiring creativity in the corporate setting. We identify a personality trait that can be useful for boards and shareholders to find CEOs who are likely to excel at innovation.

While our results highlight how sensation seeking CEOs contribute to innovation success, we do not speak to whether sensation seeking CEOs are overall good managers. More research is needed to understand situations in which sensation seeking CEOs may be detrimental to firm value.

Appendix

Variables	Description
Dependent variable	
Patent	The number of patents applied for during the year.
Citation	The number of citations summed across all patents applied for during the year. Each patent's number of citations is multiplied by the weighting index from Hall et al. (2001, 2005).
Scitation	The number of citations excluding self-citations across all patents applied for during the year.
Tcitation	The number of citations summed across all patents applied for during the year. Each patent's number of citations is scaled by the average citation count of all patents in the same technology class applied for in the same year.
Acitation	The average number of citations per patent applied for during the year.
Diversity	One minus the Herfindahl index of the patents applied for in a given year by a firm across three-digit technological classes.
Originality	One minus the Herfindahl index of the citations made by the patents applied for in a given year by a firm based on three-digit technological classes.
R&D spending	The ratio of research and development expenditures over lagged total assets, expressed as a percentage. Missing values are set to zero.
Independent variables	
Pilot CEO	An indicator variable equal to one for CEOs with a pilot license and zero otherwise.
Assets	Total assets in millions.
PPE/EMP	The ratio of net property, plant, and equipment over the number of employees.
Stock return	Firm buy-and-hold return over the fiscal year.
Tobin's *Q*	The market value of assets divided by the book value of assets where the market value of assets equals the book value of assets plus the market value of common equity less the sum of the book value of common equity and balance sheet deferred taxes.
Institutional holdings	Percentage of shares held by financial institutions.
Tenure	CEO tenure in months.

Variables	Description
Delta	Dollar change in CEO stock and option portfolio for a 1% change in stock price.
Vega	Dollar change in CEO option holdings for a 1% change in stock return volatility.
CEO age	CEO age in years.
Top university	An indicator variable equal to one if the CEO's undergraduate institution is listed as one of the top 50 schools ranked by *U.S. News & World Report* in any year during the period 1983 through 2007 and zero otherwise.
Finance education	An indicator variable equal to one if the CEO received a degree in accounting, finance, business (including MBA), or economics and zero otherwise.
Technical education	An indicator variable equal to one for CEOs with undergraduate or graduate degrees in engineering, physics, operations research, chemistry, mathematics, biology, pharmacy, or other applied science and zero otherwise.
PhD in technical education	An indicator variable equal to one for CEOs with a PhD in engineering, technology, science, or mathematics and zero otherwise.
No school information	An indicator variable equal to one if we cannot identify the CEO's undergraduate school and zero otherwise.
Military	An indicator variable equal to one for CEOs with military background and zero otherwise.
Overconfidence	An indicator variable equal to one for all years after the CEO's options exceed 67% moneyness and zero otherwise.

References

Aghion, P., Bloom, N., Blundell, R., Griffith, R., Howitt, P., 2005. Competition and innovation: An inverted-U relationship. Quarterly Journal of Economics 120, 701–728.

Ariely, D., Gneezy, U., Loewenstein, G., Mazar, N., 2009. Large stakes and big mistakes. Review of Economic Studies 76, 451–469.

Atanassov, J., 2013. Do hostile takeovers stifle innovation? Evidence from antitakeover legislation and corporate patenting. Journal of Finance 68, 1097–1131.

Benabou, R., Tirole, J., 2003. Intrinsic and extrinsic motivation. Review of Economic Studies 70, 489–520.

Benmelech, E., Frydman, C., 2015. Military CEOs. Journal of Financial Economics 117, 43–59.

Bernile, G., Bhagwat, V., Rau R., 2016. What doesn’t kill you only makes you more risk-loving: Early disasters and CEO behavior. Journal of Finance, forthcoming.

Cain, M., McKeon, S., 2016. CEO personal risk-taking and corporate policies. Journal of Financial and Quantitative Analysis 51, 139–164.

Coles, J., Daniel, N., Naveen, L., 2006. Managerial incentives and risk-taking. Journal of Financial Economics 79, 431–468.

Core, J., Guay, W., 2002. Estimating the value of employee stock option portfolios and their sensitivities to price and volatility. Journal of Accounting Research 40, 613–630.

Cronqvist, H., Makhija, A., Yonker, S., 2012. Behavioral consistency in corporate finance: CEO personal and corporate leverage. Journal of Financial Economics 103, 20–40.

Custodio, C., Ferreira, M., Matos, P., 2015. Do general managerial skills spur innovation? Unpublished working paper, University of Virginia.

Davidson, R., Dey, A., Smith, A., 2015. Executives’ “off-the-job” behavior, corporate culture, and financial reporting risk. Journal of Financial Economics 117, 5–28.

Dyer, J., Gregersen, H., Christensen, C., 2009. The innovator's DNA. Harvard Business Review 87, 60–67.

Dyer, J., Gregersen, H., Christensen, C., 2011. The Innovator's DNA: Mastering the Five Skills of Disruptive Innovators. Harvard Business Review Press, Cambridge, MA.

Ederer, F., Manso, G., 2013. Is pay for performance detrimental to innovation? Management Science 59, 1496–1513.

Fang, V., Tian, X., Tice, S., 2014. Does stock liquidity enhance or impede firm innovation? Journal of Finance 69, 2085–2125.

Fee, C., Hadlock, C., Pierce, J., 2013. Managers with and without style: Evidence using exogenous variation. Review of Financial Studies 26, 567–601.

Feist, G., 1998. A meta-analysis of personality in scientific and artistic creativity. Personality and Social Psychology Review 2, 290–309.

Galasso, A., Simcoe, T., 2011. CEO overconfidence and innovation. Management Science 57, 1469–1484.

Gibbons, R., 1998. Incentives in organizations. Journal of Economic Perspectives 12, 115–132.

Glucksberg, S., 1962. The influence of strength of drive on functional fixedness and perceptual recognition. Journal of Experimental Psychology 63, 36–41.

Graham, J., Harvey, C., Puri, M., 2013. Managerial attitudes and corporate actions. Journal of Financial Economics 109, 103–121.

Griliches, Z., 1990. Patent statistics as economic indicators: A survey. Journal of Economic Literature 28, 1661–1707.

Griliches, Z., Pakes, A., Hall, B., 1987. The value of patents as indicators of inventive activity. In: Dasgupta, P., Stoneman, P. (Eds.), Policy and Technological Performance. Cambridge University Press, London, pp. 97–124.

Grinblatt, M., Keloharju, M., 2009. Sensation seeking, overconfidence, and trading activity. Journal of Finance 64, 549–578.

Hall, B., Jaffe, A., Trajtenberg, M., 2001. The NBER patent citations data file: Lessons, insights and methodological tools. NBER Working Paper No. 8498.

Hall, B., Jaffe, A., Trajtenberg, M., 2005. Market value and patent citations. RAND Journal of Economics 36, 16–38.

Hart, O., 2010. Making the case for contract theory. American Economic Association, Ten Years and Beyond: Economists Answer NSF's Call for Long-Term Research Agendas.

Hausman, J., Hall, B., Griliches, Z., 1984. Econometric models for count data with an application to the patents-R&D relationship. Econometrica 52, 909–938.

He, J., Tian, X., 2013. The dark side of analyst coverage: The case of innovation. Journal of Financial Economics 109, 856–878.

Hellmann, T., Thiele, V., 2011. Incentives and innovation: A multitasking approach. American Economic Journal: Microeconomics 3, 78–128.

Heyman, S., Rose, K., 1980. Psychological variables affecting SCUBA performances. In: Nadeau, C., Halliwell, W., Newell, K., Roberts, G. (Eds.), Psychology of Motor Behavior and Sport. Human Kinetics Press, Champaign, IL, pp. 180–188.

Hirshleifer, D., Low, A., Teoh, S., 2012. Are overconfident CEOs better innovators? Journal of Finance 67, 1457–1498.

Holmstrom, B., 1989. Agency costs and innovation. Journal of Economic Behavior and Organization 12, 305–327.

Kish, G., Donnenwerth, G., 1969. Interests and stimulus seeking. Journal of Counseling Psychology 16, 551–565.

Kogan, L., Papanikolaou, D., Seru, A., Stoffman, N., 2016. Technological innovation, resource allocation, and growth. Quarterly Journal of Economics, forthcoming.

Lopez-Bonilla, J., Lopez-Bonilla, L., 2012. Sensation-seeking profiles and personal innovativeness in information technology. Social Science Computer Review 30, 434–447.

Malmendier, U., Nagel, S., 2011. Depression babies: Do macroeconomic experiences affect risk taking? Quarterly Journal of Economics 126, 373–416.

Malmendier, U., Tate, G., 2005. CEO overconfidence and corporate investment. Journal of Finance 6, 2661–2700.

Malmendier, U., Tate, G., 2008. Who makes acquisitions? CEO overconfidence and the market's reaction. Journal of Financial Economics 89, 20–43.

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

Manso, G., 2011. Motivating innovation. Journal of Finance 66, 1823–1860.

Mittelstaedt, R., Grossbart, S., Curtis, W., DeVere, S., 1976. Optimal stimulation level and the adoption decision process. Journal of Consumer Research 3, 84–94.

Pakes, A., Griliches, Z., 1980. Patents and R&D at the firm level: A first report. Economics Letters 5, 377–381.

Roberti, J., 2004. A review of behavioral and biological correlates of sensation seeking. Journal of Research in Personality 38, 256–279.

Seru, A., 2014. Firm boundaries matter: Evidence from conglomerates and R&D activity. Journal of Financial Economics 111, 381–405.

Zuckerman, M., 1971. Dimensions of sensation seeking. Journal of Consulting and Clinical Psychology 36, 45–52.

Zuckerman, M., 1994. Behavioral Expressions and Biological Bases of Sensation Seeking. Cambridge University Press, Cambridge.

Zuckerman, M., 2007. Sensation Seeking and Risky Behavior. American Psychological Association, Washington DC.

Zuckerman, M., Eysenck, S., Eysenck, H., 1978. Sensation seeking in England and America: Cross-cultural, age, and sex comparisons. Journal of Consulting and Clinical Psychology 46, 139–149.

Table 1
Distribution of CEO pilots by certificate category

This table provides pilot certificate information for the CEOs in the sample. There are 88 pilot CEOs identified in this study. Panel A reports the certificate levels attained by the pilot CEOs. Panel B displays the number of pilot CEOs by certain certificate ratings. The rating categories are not mutually exclusive.

Panel A: Distribution of CEO pilots by certificate level

Category	No.
Pilot certificate level	
Student pilot	7
Private pilot	60
Commercial pilot	13
Airline transport pilot	8
Total	88

Panel B: Distribution of CEO pilots by certificate rating

Rating	No.
Single engine airplane	79
Multiengine airplane	23
Helicopter	6
Glider	1
Sea landing	6
Instrument rating	44

Table 2

Distribution of the sample by year and industry

This table provides the breakdown of the number of CEOs, the number of pilot CEOs, and the percentage of pilot CEOs in the sample by year (Panel A) and by industry excluding financial firms and utilities (Panel B). The sample of CEOs is from ExecuComp for the period 1993–2003.

Panel A: Sample distribution by year

Year	No. of CEOs	No. of Pilot CEOs	Pilot CEOs (%)
1993	107	7	6.54
1994	198	11	5.56
1995	264	15	5.68
1996	331	20	6.04
1997	374	25	6.68
1998	427	33	7.73
1999	481	39	8.11
2000	538	50	9.29
2001	566	48	8.48
2002	584	52	8.90
2003	624	49	7.85
Total	4,494	349	7.77

Panel B: Sample distribution by Fama French 12 industry groups

Industry	No. of CEOs	No. of Pilot CEOs	Pilot CEOs (%)
Consumer nondurables	231	15	6.49
Consumer durables	257	7	2.72
Manufacturing	1,188	93	7.83
Energy	115	26	22.61
Chemicals and allied products	373	13	3.49
Business equipment	1,477	143	9.68
Telecommunication	97	6	6.19
Shops	78	3	3.85
Health	458	21	4.59
Other	220	22	10.00
Total	4,494	349	7.77

Table 3

Summary statistics

This table presents summary statistics of the variables used in this study. *t*-tests (Wilcoxon-Mann-Whitney tests) are conducted to test for differences between the means (medians) for firms with and without pilot CEOs. Variable definitions are provided in the Appendix. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Non-pilot CEO				Pilot CEO			
Variable	N	Mean	Median	Std. dev.	N	Mean	Median	Std. dev.
Dependent variables								
Patent	4,145	45.61	3.00	203.07	349	78.83***	4.00**	256.44
Citation	4,145	613.21	7.59	3,837.80	349	1,252.24***	23.37***	5,251.92
Diversity	2,336	0.69	0.75	0.22	215	0.71	0.80**	0.24
Originality	2,626	0.77	0.83	0.20	239	0.79	0.85	0.19
R&D spending	4,145	6.26	2.73	10.90	349	7.41*	4.08*	10.27
Other variables								
Assets (millions)	4,145	6,491	1,112	25,806	349	5,473	1,173	11,756
PPE/EMP	4,145	87.69	46.58	127.49	349	121.00***	52.08***	205.24
Stock return (%)	4,145	21.95	9.11	88.86	349	19.45	6.37	72.68
Tobin's *Q*	4,145	2.46	1.69	2.95	349	2.37	1.69	2.02
Institutional holdings (%)	4,145	60.66	63.12	18.25	349	61.84	65.02	17.96
Tenure (months)	4,145	42.67	35.00	30.52	349	43.81	36.00	30.60
Delta	4,145	928.86	162.71	7,132.14	349	868.59	168.63	4,035.81
Vega	4,145	70.72	16.22	229.57	349	124.72***	30.12***	330.47
CEO age (years)	4,145	51.01	52.00	7.31	349	48.21***	49.00***	6.88
Top university	4,145	0.32	--	--	349	0.27*	--	--
Finance education	4,145	0.55	--	--	349	0.54	--	--
Technical education	4,145	0.46	--	--	349	0.48	--	--
PhD in technical education	4,145	0.06	--	--	349	0.09*	--	--
No school information	4,145	0.06	--	--	349	0.04*	--	--
Military	4,145	0.09	--	--	349	0.25***	--	--
Overconfidence	4,145	0.51	--	--	349	0.52	--	--

Table 4

Relation between pilot CEO and patenting activities

This table presents the results of the effect of pilot CEOs on patent and citation counts. Columns 1 and 2 report the estimates from a Poisson model. Columns 3 and 4 report the estimates from a zero-inflated Poisson model. Columns 5 and 6 report the estimates from OLS regressions. *Patent* is the number of patents applied for during the year. *Citation* is the number of raw citations multiplied by the weighting index of Hall et al. (2001, 2005) to all the patents applied for during the year. *Pilot CEO* is an indicator variable equal to one if the CEO has been a pilot and zero otherwise. Independent variables are lagged by one year. All continuous independent variables are scaled to have zero mean and standard deviation of one. Variable definitions are provided in the Appendix. Regressions include year and industry fixed effects. Standard errors are clustered at the firm level and *z*- or *t*-statistics are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Poisson		Zero-inflated Poisson		OLS	
	(1)	(2)	(3)	(4)	(5)	(6)
	Patent	Citation	Patent	Citation	Log(1+patent)	Log(1+citation)
Pilot CEO	0.583***	0.460***	0.511***	0.364**	0.334**	0.618**
	(3.02)	(2.77)	(2.74)	(2.35)	(1.97)	(2.40)
Log(assets)	1.687***	1.674***	1.548***	1.504***	1.178***	1.509***
	(18.07)	(18.54)	(18.15)	(17.70)	(16.84)	(15.74)
Log(PPE/EMP)	0.136	0.292**	0.164	0.366***	0.006	0.004
	(0.96)	(2.34)	(1.10)	(2.88)	(0.11)	(0.04)
Stock return	0.064**	0.065**	0.066**	0.068**	-0.002	0.029
	(2.34)	(2.14)	(2.51)	(2.27)	(-0.07)	(0.75)
Tobin's *Q*	0.044	0.060*	0.021	0.037	0.173***	0.234***
	(1.39)	(1.70)	(0.67)	(1.01)	(3.00)	(2.98)
Institutional holdings (%)	-0.110*	-0.149***	-0.118**	-0.167***	-0.180***	-0.172***
	(-1.94)	(-2.61)	(-2.17)	(-3.06)	(-4.23)	(-2.75)
Log(1+tenure)	0.123*	0.126*	0.107	0.110	0.019	0.018
	(1.69)	(1.71)	(1.54)	(1.62)	(0.56)	(0.34)
Log(1+delta)	-0.056	-0.024	-0.082	-0.043	0.037	0.066
	(-0.79)	(-0.36)	(-1.25)	(-0.67)	(0.80)	(0.93)
Log(1+vega)	-0.020	-0.045	-0.007	-0.017	0.078**	0.081
	(-0.55)	(-1.11)	(-0.19)	(-0.42)	(2.08)	(1.41)

Log(CEO age)	-0.152	*	-0.275	***	-0.139	*	-0.256	***	-0.003		-0.022	
	(-1.82)		(-3.99)		(-1.78)		(-4.16)		(-0.09)		(-0.36)	
Top university	0.113		-0.001		0.154		0.036		-0.131		-0.202	
	(0.92)		(-0.01)		(1.34)		(0.29)		(-1.45)		(-1.48)	
Finance education	0.138		0.345	**	0.132		0.315	**	0.140		0.213	
	(1.12)		(2.41)		(1.14)		(2.26)		(1.64)		(1.64)	
Technical education	0.102		0.113		0.133		0.155		-0.006		0.033	
	(0.72)		(0.77)		(0.98)		(1.13)		(-0.06)		(0.25)	
PhD in technical education	0.243		0.244		0.156		0.104		0.636	***	0.987	***
	(1.36)		(1.34)		(0.92)		(0.60)		(3.52)		(3.63)	
No school information	-0.781	***	-0.304		-0.773	***	-0.221		-0.346	**	-0.469	*
	(-2.85)		(-0.79)		(-2.78)		(-0.58)		(-2.21)		(-1.84)	
Military	-0.067		-0.013		-0.033		0.083		0.012		0.049	
	(-0.41)		(-0.06)		(-0.23)		(0.41)		(0.08)		(0.23)	
Overconfidence	0.301	**	0.511	***	0.312	**	0.494	***	0.102		0.124	
	(2.41)		(4.50)		(2.56)		(4.62)		(1.28)		(1.00)	
Observations	4,494		4,494		4,494		4,494		4,494		4,494	

Table 5
Relation between pilot CEO and R&D spending

This table presents the results from OLS regressions of *R&D spending* on *Pilot CEO*. *R&D spending* is the ratio of R&D to lagged total assets, expressed as a percentage. Firm control variables are *Log(assets)*, *Log(PPE/EMP)*, *Stock return*, *Tobin's Q*, and *Institutional holdings*. Independent variables are lagged by one year. All continuous independent variables are scaled to have zero mean and standard deviation of one. Variable definitions are provided in the Appendix. Regressions include year and industry fixed effects. Standard errors are clustered at the firm level and *t*-statistics are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	R&D spending	
Pilot CEO	1.138	
	(1.18)	
Log(1+tenure)	0.160	
	(0.75)	
Log(1+delta)	-0.431	
	(-0.98)	
Log(1+vega)	1.412	***
	(5.45)	
Log(CEO age)	-0.134	
	(-0.41)	
Top university	0.429	
	(0.69)	
Finance education	0.225	
	(0.47)	
Technical education	1.524	***
	(2.99)	
PhD in technical education	2.916	
	(1.58)	
No school information	-1.018	
	(-1.18)	
Military	-0.307	
	(-0.50)	
Overconfidence	1.676	***
	(3.30)	
Firm controls	Yes	
Observations	4,494	

Table 6

Relation between pilot CEO and innovation effectiveness

This table presents the results from zero-inflated Poisson regressions of patent count and citation count on *Pilot CEO*, controlling for *R&D spending*. Firm control variables are *Log(assets)*, *Log(PPE/EMP)*, *Stock return*, *Tobin's Q*, and *Institutional holdings*. Independent variables are lagged by one year. All continuous independent variables are scaled to have zero mean and standard deviation of one. Variable definitions are provided in the Appendix. Regressions include year and industry fixed effects. Standard errors are clustered at the firm level and *z*-statistics are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)
	Patent	Citation
Pilot CEO	0.525 ***	0.388 **
	(2.82)	(2.51)
R&D spending	0.059	0.080 **
	(1.60)	(2.05)
Log(1+tenure)	0.101	0.103
	(1.40)	(1.48)
Log(1+delta)	-0.081	-0.043
	(-1.24)	(-0.67)
Log(1+vega)	-0.002	-0.010
	(-0.05)	(-0.26)
Log(CEO age)	-0.128	-0.245 ***
	(-1.54)	(-3.89)
Top university	0.156	0.041
	(1.36)	(0.34)
Finance education	0.131	0.313 **
	(1.13)	(2.26)
Technical education	0.132	0.150
	(0.96)	(1.08)
PhD in technical education	0.135	0.070
	(0.81)	(0.40)
No school information	-0.759 ***	-0.196
	(-2.77)	(-0.53)
Military	-0.034	0.086
	(-0.23)	(0.43)
Overconfidence	0.303 **	0.484 ***
	(2.45)	(4.54)
Firm controls	Yes	Yes
Observations	4,494	4,494

Table 7

Relation between pilot CEO and patent characteristics

This table presents the results from OLS regressions of measures of patent characteristics on *Pilot CEO*. *Diversity* is one minus the Herfindahl index of the patents applied for in a given year by a firm across three-digit technological classes, and *Originality* is one minus the Herfindahl index of the citations made by the patents applied for in a given year by a firm based on three-digit technological classes. Innovative firms are firms reporting positive R&D during the sample period. Firm control variables are *Log(assets)*, *Log(PPE/EMP)*, *Stock return*, *Tobin's Q*, and *Institutional holdings*. Independent variables are lagged by one year. All continuous independent variables are scaled to have zero mean and standard deviation of one. Variable definitions are provided in the Appendix. Regressions include year and industry fixed effects. Standard errors are clustered at the firm level and *t*-statistics are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)
	Diversity	Diversity in innovative firms	Originality	Originality in innovative firms
Pilot CEO	0.029	0.038**	0.029*	0.037**
	(1.52)	(2.00)	(1.79)	(2.38)
Log(1+tenure)	-0.001	0.002	0.001	0.003
	(-0.14)	(0.35)	(0.12)	(0.68)
Log(1+delta)	-0.005	-0.010	0.009	0.009
	(-0.60)	(-1.16)	(1.52)	(1.44)
Log(1+vega)	0.011*	0.012*	0.003	0.002
	(1.92)	(1.94)	(0.70)	(0.50)
Log(CEO age)	0.004	0.004	0.003	0.001
	(0.62)	(0.53)	(0.48)	(0.12)
Top university	-0.022*	-0.017	-0.012	-0.007
	(-1.67)	(-1.22)	(-1.05)	(-0.65)
Finance education	0.017	0.017	0.013	0.015
	(1.30)	(1.26)	(1.27)	(1.37)
Technical education	0.031**	0.030**	0.023**	0.016
	(2.47)	(2.23)	(2.24)	(1.52)
PhD in technical education	0.004	-0.001	0.025	0.025
	(0.17)	(-0.06)	(1.65)	(1.61)
No school information	-0.017	-0.020	-0.035	-0.035
	(-0.60)	(-0.66)	(-1.42)	(-1.35)
Military	0.008	0.006	0.013	0.007
	(0.41)	(0.29)	(0.78)	(0.41)
Overconfidence	0.003	-0.001	-0.005	-0.009
	(0.22)	(-0.06)	(-0.51)	(-0.90)
Firm controls	Yes	Yes	Yes	Yes
Observations	2,551	2,373	2,865	2,629

Table 8

Stock market returns around patent-grant dates

This table presents the results from OLS regression of cumulative abnormal returns (*CARs*) around patent-grant dates on *Pilot CEO*. *CARs* are cumulative size-adjusted returns, calculated as the raw return net of the CRSP size-decile portfolio return, during the three-day window [0, +2] around patent-grant dates. *Number of patents* refers to the number of patents granted to the firm on the same day. *Average tenure* (*delta, vega, CEO age*) is computed as the mean of the values of tenure (delta, vega, CEO age) corresponding to the patents granted to the firm on the same day. The independent variables are computed one year before the patent application year. We require that the CEO be the same one when the independent variables and the dependent variable are estimated. All continuous independent variables are scaled to have zero mean and standard deviation of one. Variable definitions are provided in the Appendix. Standard errors are clustered at the firm level and *t*-statistics are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	CARs	
Pilot CEO	0.150	**
	(2.07)	
Log(number of patents)	-0.025	
	(-1.15)	
Average tenure	-0.021	
	(-0.88)	
Average delta	0.018	
	(0.64)	
Average vega	-0.038	*
	(-1.65)	
Average CEO age	-0.061	***
	(-2.77)	
Top university	-0.045	
	(-1.10)	
Finance education	-0.021	
	(-0.43)	
Technical education	0.025	
	(0.55)	
PhD in technical education	0.102	
	(1.48)	
No school information	0.020	
	(0.16)	
Military	-0.066	
	(-1.26)	
Overconfidence	0.077	
	(1.55)	
Observations	47,320	

Table 9

CEO turnover analysis

This table presents the results from OLS regressions of change in patent and citation counts on change in *Pilot CEO* after controlling for change in other CEO characteristics and change in firm controls, with changes computed in three different periods, namely, from year –1 to year 1 through year 3. Year 0 is the CEO turnover year. Firm control variables are *Log(assets)*, *Log(PPE/EMP)*, *Stock return*, *Tobin's Q*, and *Institutional holdings*. Variable definitions are provided in the Appendix. *t*-statistics are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Year -1 to Year 1		Year -1 to Year 2		Year -1 to Year 3	
	(1)	(2)	(3)	(4)	(5)	(6)
	ΔLog(1+patent)	ΔLog(1+citation)	ΔLog(1+patent)	ΔLog(1+citation)	ΔLog(1+patent)	ΔLog(1+citation)
Δ Pilot CEO	0.054	0.279	0.559 *	0.695 *	0.804 **	1.238 **
	(0.29)	(1.11)	(1.79)	(1.89)	(2.10)	(2.43)
Δ Log(1+tenure)	-0.042	0.058	0.028	-0.007	-0.054	0.045
	(-0.49)	(0.51)	(0.18)	(-0.04)	(-0.24)	(0.15)
Δ Log(1+delta)	0.088 *	0.086	0.017	0.114	-0.020	0.064
	(1.84)	(1.31)	(0.19)	(1.13)	(-0.18)	(0.44)
Δ Log(1+vega)	0.005	-0.021	0.112	-0.046	0.087	0.041
	(0.14)	(-0.42)	(1.62)	(-0.57)	(1.07)	(0.38)
Δ Log(CEO age)	-0.239	-0.435	0.495	-0.358	0.061	-1.172
	(-0.69)	(-0.92)	(0.72)	(-0.44)	(0.07)	(-0.97)
Δ Top university	-0.153	-0.176	0.092	0.049	-0.050	0.121
	(-1.49)	(-1.25)	(0.56)	(0.25)	(-0.26)	(0.47)
Δ Finance education	0.043	0.043	0.098	-0.215	0.101	-0.214
	(0.42)	(0.31)	(0.55)	(-1.02)	(0.45)	(-0.72)
Δ Technical education	0.041	0.271 *	-0.358 *	-0.082	-0.065	0.206
	(0.38)	(1.85)	(-1.89)	(-0.37)	(-0.31)	(0.72)
Δ PhD in technical education	0.251	0.072	0.395	0.129	-0.160	-0.604
	(1.14)	(0.24)	(1.06)	(0.30)	(-0.35)	(-0.99)
Δ No school information	0.177	0.295	-0.102	-0.514	-0.032	-0.273
	(0.90)	(1.10)	(-0.28)	(-1.20)	(-0.07)	(-0.47)

Δ Military	0.029	0.173	-0.037	-0.100	0.227	0.380
	(0.20)	(0.87)	(-0.15)	(-0.34)	(0.74)	(0.93)
Δ Overconfidence	0.026	0.151	0.189	0.256	0.392 *	0.464
	(0.24)	(1.04)	(1.07)	(1.23)	(1.72)	(1.54)
Δ Firm controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	190	190	136	136	83	83