Inventor CEOs*

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Abstract

One-in-five U.S. high-technology firms are led by CEOs with hands-on innovation experience as inventors. Firms led by "Inventor CEOs" are associated with higher quality innovation, especially when the CEO is a high-impact inventor. During an Inventor CEO's tenure, firms file a greater number of patents and more valuable patents in technology-classes where the CEO's hands-on experience lies. Utilizing plausibly exogenous CEO turnovers to address the matching of CEOs to firms suggests these effects are causal. The results can be explained by an Inventor CEO's superior ability to evaluate, select and execute innovative investment projects related to their own hands-on experience.

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"Innovation has nothing to do with how many R&D dollars you have. When Apple came up with the Mac, IBM was spending at least 100 times more on R&D. It's not about money. It's about the people you have, how you're led, and how much you get it." - Steve Jobs, former CEO, Apple Inc.

1 Introduction

A CEO's personal "style" can have a significant impact on corporate policies and performance (Bertrand and Schoar (2003)). One important, yet unexplored aspect of a CEO's personal background that can influence their style, is the extent to which they possess hands-on innovation experience as an inventor. In this study, we examine whether this dimension of a CEO's personal background impacts upon a firm's innovation activities.

To understand why a CEO's hands-on inventor experience should matter, we draw upon the learning-by-doing literature. This literature contends that hands-on experience is a critical channel through which individuals acquire and refine specialized skills (see Arrow (1962), Alchian (1963) and Irwin and Klenow (1994)).[1] In our context, a CEO's inventor experience may endow them with valuable innovation-related insights that translate into a superior ability to evaluate, select and execute innovation-intensive investment projects for the firms they lead.

An anecdote that helps to illustrate the validity of this hypothesis in practice is provided by Sanjay Mehrotra, the CEO of Sandisk, but also an inventor with more than 70 patents registered in his name. In describing how his inventor experience has enhanced his executive capabilities he notes: "*It's helped me a great deal in understanding the capabilities of our technology, and in assessing the complexities of the challenges ahead. That makes a big*

[1] The learning-by-doing literature encompasses a broad range of disciplines including education, psychology and economics. Starting with Arrow (1962) the concept was used to understand labor productivity. Our argument that certain innovation-related insights can only be acquired through hands-on experience, aligns well with Arrow's notion that "*Learning can only take place through the attempt to solve a problem and therefore only takes place during activity*". See Thompson (2010) for a review of learning-by-doing in economics.

difference in determining strategic plans and in managing execution. It becomes easier to focus attention on the right issues".[2]

Hands-on experience has also been shown to explain the quality of individual decision making in somewhat related settings. Bradley, Gokkaya and Liu (2017) find that a security analyst's prior work experience in an industry is associated with greater forecast accuracy on stocks in industries where this experience lies. Similarly, Cai, Sevilir and Tian (2015) show that venture capitalists with experience as entrepreneurs enhance the performance of their VC funds.[3] Echoing the logic underlying our hypothesis, both studies suggest that hands-on experience provides individual agents with unique information advantages in evaluating investment opportunities.[4]

Yet, the relationship between Inventor CEOs and corporate innovation is not obvious. While technically adept, Inventor CEOs may not be as capable of marketing or commercializing their firm's technologies. Further, inventors may have difficulty accepting ideas that lie outside the domain of their specific expertise (Christensen (1997)).[5] For related reasons, venture capitalists often replace technical founders with professional management teams (Hellman and Puri (2002)). Thus, whether an inventor background enhances a CEO's ability to successfully stimulate firm-wide innovation is an open empirical question.

To determine the effect of a CEO's inventor experience on their firm's innovation, we assemble a novel hand collected dataset that tracks the patenting history of CEOs in U.S.

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[2] See https://www.forbes.com/sites/georgeanders/2012/07/16/geniuses-or-dabblers/#407ca405231a

[3] The academic profession provides another anecdote regarding why hands-on "doing" experience matters when evaluating innovation. Evaluating a paper's scholarly innovation is exclusively entrusted to those with proven hands-on experience "doing" innovative research (journal editors and referees).

[4] Relatedly, some studies show that professional end-users of products play an important role in innovation because their hands-on knowledge of a product can help to identify new applications and important incremental improvements (see Shah and Tripsas (2007) and Laursen (2011)).

[5] Several anecdotes from industry attest to such concerns. For example, The MIT Centre for Entrepreneurship has made it mandatory that an inventor cannot be the founding CEO of a spin off, see https://riccentre.ca/2009/09/the-imperative-for-non-inventor-ceos/. Also see "Should the Inventor Be CEO? http://www.inventioncity.com/inventors /inventors-are-rarely-good-managers-and-ceos.

high-technology firms in the S&P1500, over a 17-year period prior to the start date of our analysis. CEOs that are awarded at least one patent in their own name are designated as "Inventor CEOs". We document the presence of Inventor CEOs in 23% of all firms and 18.7% of all firm-years in our sample. We focus on the U.S. high-technology sector for two primary reasons. First, this sector accounted for virtually the entire U.S. R&D boom, especially young firms in these industries (Brown, Fazzari and Petersen (2009)). Second, since top executives with technical backgrounds are concentrated in high-technology industries (see Hambrick, Black and Fredrickson (1992)), focusing on these industries creates a balanced sample of Inventor CEO-led firms and an appropriate set of counterfactuals.

Our baseline analysis reveals that firms led by Inventor CEOs are associated with a greater volume of registered patents, more valuable and highly cited patents and greater innovation efficiency. Inventor CEO-led firms are also more likely to spur ground-breaking or disruptive innovations, shown by their greater propensity to produce patents that are cited in the 99^{th} percentile of the citation distribution within their technology class-year.

This positive correlation between Inventor CEOs and corporate innovation needs to be interpreted with caution. Inventor CEOs and/or the firms they lead could be self-selected based on unobservable characteristics that can also explain more successful innovation. One way to address such concerns is to analyze variations among only Inventor CEO-led firms. If a CEO's hands-on inventor experience does indeed drive the above positive correlation, then this effect should be stronger for Inventor CEOs with higher quality inventor experience. Our results show that Inventor CEOs with a history of high-impact patents have an economically stronger association with successful firm-level innovation, relative to low-impact Inventor CEOs.

We next attempt to tie the specific technology class experience of an Inventor CEO more closely to their firm's innovation outputs. If an Inventor CEO's advantage lies in being able to more effectively evaluate and execute innovative investment projects, then this advantage should be most discernibly realized in technology classes related to their own hands-on experience.[6] To test this conjecture, we categorize each Inventor CEO's individual patenting experience *before* becoming CEO into discrete technology classes and analyze whether this experience is reflected in the technology class distribution of patents filed by the firm during their tenure. We find that technology classes in which an Inventor CEO possesses hands-on experience are associated with a 22 percent greater patent output. Patents filed in these technology classes are also more economically valuable and scientifically important. Within Inventor CEO-led firms, patents filed in technology classes aligned with the CEO's experience are on average worth $549,000 more than patents in other technology classes. These patents are also significantly more likely to be cited in the 99th percentile of the citation distribution within their technology class-year.

Our analysis of variations among the Inventor CEO sample also uncovers a novel fact. Almost half of all Inventor CEOs continue to file patents in their own name *during* their tenure as CEO.[7] We designate CEOs that are named inventors on their firms' patents during their tenure, as "active" Inventor CEOs.[8] Since an active Inventor CEO's experience is aligned with their firm's current innovation activities, their innovation insights may be especially valuable to the firm. Further, an active Inventor CEO's hands-on *involvement* in their firm's innovation may breed a more innovation-centric leadership style that can also

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[6] Examining how an Inventor CEO's technology class experience is reflected in the innovation outputs of their firm can also be interpreted as a CEO imposing their idiosyncratic style on the firm (Bertrand and Schoar (2003)).

[7] Reconciling a CEO's everyday activities with being an active inventor can seem somewhat perplexing. A Silicon Valley patent lawyer clarifies how this works in practice. "*…a lot of innovation is going to involve user-level features. That's what CEOs think about in their day job. Those innovations don't require expensive labs. They can be sketched out on a white board. In fact, you can develop them sufficiently in an hour or two to support a patent application.*" see https://www.forbes.com/sites/georgeanders/2012/07/16/geniuses-or-dabblers/#7fda011b231a

[8] An example of an active Inventor CEO is Netflix's Reed Hastings. One of Netflix's important yet simple innovations was the proprietary design of a DVD envelope that allowed safe and cost effective shipping. Patent records show Hastings was a co-inventor of the envelop design during his tenure as CEO.

spur greater innovation.[9] Our results show that the presence of an active Inventor CEO is more strongly associated with a firm's patent impact and volume relative to non-active Inventor CEOs. These results hold even when excluding firm patents on which the CEO is a named inventor.

The correlation we establish between Inventor CEOs and corporate innovation can be interpreted in at least two ways. First, firms with higher innovation potential may optimally hire Inventor CEOs because they have the relevant skillset to achieve the firm's objectives (i.e. assortative matching).[10] For example, a firm may wish to innovate in a promising new technology class, and thus hires an Inventor CEO with relevant experience in this class. The second interpretation is that Inventor CEOs may be imprinting their idiosyncratic "style" on the firm by exploiting their learning-by-doing advantage to pursue innovation-intensive investment opportunities in technology classes related to their own experience. It is important to note that both interpretations imply that Inventor CEOs possess a unique innovation enhancing skillset. Thus, we believe that the correlations we document are in themselves an important new contribution of our paper. Nonetheless, it is only under the second interpretation that one can deduce that it is not just a firm's optimal strategy driving its innovation outcomes, but that an Inventor CEO plays a causal role in forming and executing their firm's innovation strategy.

To provide causal evidence on the effect of Inventor CEOs, we study plausibly exogenous Inventor CEO turnover events (e.g. sudden deaths, health shocks etc.). We show that firms switching from Inventor to non-Inventor CEOs experience an economically sizable and statistically significant decline in corporate innovation outputs and impact, relative to a carefully matched set of control firms that also experience a plausibly exogenous CEO

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[9] Studies in the management literature suggest that CEOs with a transformational (as opposed to a transactional) leadership style that intellectually engage with their employees, create a corporate culture more conducive to innovation (see Bass and Avolio (1993, 1994), Jung, Chow and Wu (2003))

[10] Pan, Siegel and Wang (2017) suggest that a firm's existing risk culture determines the type of leader they select.

turnover, except from a non-Inventor to another non-Inventor CEO.

We next exploit our firm technology class-level data to study how the same CEO turnovers alter the technological focus of a firm's innovation. We analyze whether the plausibly exogenous departure of an Inventor CEO alters the number and impact of new patents filed by a firm in technology classes where the outgoing Inventor CEO has hands-on experience, relative to a counterfactual set of technology classes where they do not. We find that a switch from an Inventor to a non-Inventor CEO significantly reduces the number, impact and value of new patents filed in technology classes where the outgoing Inventor CEO's experience lies.

We attempt to rule out several alternative explanations for our story. First, it is plausible that many Inventor CEOs are also founder CEOs and it is in fact a founder effect that is driving our results. Excluding founder-led firms from our analysis or including a founder CEO dummy in our empirical specifications, leaves our results qualitatively unchanged. Second, the Inventor CEO variable may just be picking up a CEO's technical expertise, and not necessarily their inventor experience per se. To deal with this, we control for a CEO's technical education (having an undergraduate degree or a Ph.D. in Science, Technology, Engineering, and Mathematics) and find our results continue to hold. Third, Inventor CEOs may just be a subset of corporate executives with specialist management skills suited to high-tech firms (rather than inventor experience). We use the General Ability Index from Custodio, Ferreira and Matos (2017) to account for the nature of a CEO's life-time executive experience and continue to find that Inventor CEOs have a positive incremental effect on corporate innovation outcomes.

The results are also robust to alternative econometric estimation techniques (Poisson, negative binomial and propensity score matching models) and the inclusion of a host of other control variables that account for other potentially confounding explanations. These include

CEO overconfidence (Hirshleifer, Low and Teoh (2012)), CEO incentives (e.g. CEOs' ownership, equity-based pay, CEO delta, CEO vega), and internal and external corporate governance (e.g. board size, board independence, and institutional holdings).

We next investigate the firm-value implications of Inventor CEOs. The superior innovation performance of Inventor CEO-led firms may result from an over-investment in innovation. While an Inventor CEO increases a firm's innovation output, he/she may lack the ability to evaluate the commercial potential of this innovation and thus harm shareholder value. Further, active Inventor CEOs may become distracted from their core executive duties, which could be also detrimental to firm value. Using a simple OLS regression, we document a positive correlation between Inventor CEO-run firms and firm value. To make stronger causal claims about this result, we employ the same set of exogenous Inventor CEO turnovers used above and find that a transition from an Inventor to a non-Inventor CEO leads to a significant reduction in firm value.

Finally, we further analyze whether Inventor CEOs possess a superior ability to select innovative investment projects by studying their corporate acquisitions decisions. The existence of superior Inventor CEO investment selection skill generates several deal-level predictions in the M&A market. Bidders in the M&A market can face a winner's curse problem (Thaler (1988), Barberis and Thaler (2003), Baker, Ruback, and Wurgler (2007)). This problem is most severe when the target's valuation is uncertain and when some bidders are more informed than others. If Inventor CEOs are more informed about the true value of innovation-intensive target firms, then fearing the winners curse, competing bidders would in equilibrium, stay away from competing on these targets. Conversely, Inventor CEOs should optimally target firms which allow them to exploit their information advantage. The lack of bidder competition for such firms should also allow them to generate greater value.

We find evidence consistent with the above arguments. Inventor CEO-run firms are more likely to acquire high-tech firms with high information asymmetry and firms with patent portfolios (i.e. innovative firms that are harder to value). We also show that when Inventor CEOs acquire such targets, their firms attract significantly higher acquirer announcements returns relative to acquirers led by non-Inventor CEOs. These effects are stronger for high-impact and active Inventor CEOs.

While the results so far indicate that Inventor CEOs possess superior investment selection skill, this does not necessarily imply that they are better able to execute innovative investment projects. This is ultimately determined by whether a firm's products (the investment output) achieve traction with customers. Thus, we also study new product announcements made by Inventor CEO-led firms. We show that Inventor CEOs make more breakthrough new product announcements and the stock market reacts more positively to these announcements relative to those made by non-Inventor CEOs.

The channels we identify may not be the only reasons that a CEO's inventor experience matters. For example, Inventor CEOs may create an innovation-centric corporate culture which cannot be easily measured or observed. An active Inventor CEO's first-hand connection to their firm's innovation may naturally make them a better salesperson of their firm's technology. Alternatively, a CEO's inventor background may be proxying for other hard-to-measure CEO characteristics that influence innovation, such as their creativity.[11]

Our findings provide a new human capital-based explanation for why some firms are more successful at innovation than others. More specifically, we uncover a new aspect of a CEO's career experience that positively impacts on a firm's ability to successfully innovate. This builds on recent work that also documents how other dimensions of CEO heterogeneity positively affect corporate innovation, such as CEO overconfidence (Hirshleifer et al. (2012),

[11] A major global survey of CEOs conducted by IBM identifies creativity as the single most important characteristic for CEO success. See https://www-03.ibm.com/press/us/en/pressrelease/31670.wss. Other studies have also suggested CEO personality traits, such as openness to new experiences and risk tolerance, influence corporate innovation (see Gow, Kaplan, Larcker and Zakolyukina, (2016), Tian and Wang (2016) and Acemoglu, Akcigit and Celik (2014)).

general managerial skill (Custodio et al. (2017)) and sensation seeking (Sunder et al. (2017)).

More broadly, our findings complement a growing body of research into how variations in CEO characteristics and career experiences are reflected in various firm outcomes. For instance, Schoar and Zhou (2017) and Dittmar and Duchin (2015) respectively show that the early macro-economic work environment and firm-specific distress experience impact upon a CEO's style. Benmelech and Frydman (2014) find that military experience also shapes CEO style. Daellenbach, McCarthy and Schoenecker (1999) find that CEOs' with technical work experience are associated with higher R&D spending, while Custodio and Metzger (2013, 2014) drill down into a CEO's industry-specific skillset and find that this can explain announcement returns to corporate acquisitions as well as corporate policies and firm value.[12]

2 Data

2.1 Sample selection

Our sample comprises high-tech publicly traded firms in the S&P 1500 from 1992-2008 for which we have reliable data on CEO characteristics from ExecuComp. We define a firm as being in a high-tech industry based on the classification in Loughran and Ritter (2004).[13] We focus on high-tech firms because i) the lion's share of innovation takes place in high-tech industries (Brown et al. (2009)), and ii) top executives with technical backgrounds are concentrated in these industries, where such experience is directly relevant (Hambrick, Black and Fredrickson (1992)). Examining other industries would most likely result in insufficient variation across Inventor and non-Inventor CEOs.

For a firm to be included in our sample, we first require that it is present in the

[12] A related literature examines the effects of early life experience and cultural and familial factors on CEO decision making (see Nguyen, Hagendorff and Eshraghi (2017), Bernile, Bhagwat and Rau (2017), Pan, Siegel and Wang (2017) and Custodio and Siegel (2017)).

[13] These industries include computer hardware, communications equipment, navigation equipment, measuring and controlling devices, medical instruments, telephone equipment, communications services, and software.

Kogan, Papanikolaou, Seru and Stoffman (2017) (henceforth KPSS) patent dataset. The KPSS patent dataset allows us to observe the patenting activity of each firm in our sample based on patents filed at the U.S. Patent and Trademark Office (USPTO) from 1926-2010. The dataset provides information on the number of patents, the market value of patents and the number of citations received by each patent filed with the USPTO. We follow the innovation literature and date the patents by the year of their application (Hall, Grilches and Hausman (1986)). This also ensures that anomalies caused by the time lag between the application and grant date of a patent are taken care of. We restrict the sample to patent applications up until 2008 considering that patents applied for after 2008 may not appear in the dataset until 2010 (the final year of data) because of the time lag in granting patents. We rely on a firm's PERMNO (provided in KPSS) to merge the firm-level patent data with Compustat and CRSP.

2.2 Classifying Inventor CEOs

We next focus on documenting the inventor history of each CEO in the sample. We use the US Patent Inventor Database from Li et al. (2014) (henceforth PID) to identify CEOs in our panel who have been awarded patents. This dataset contains more than 8 million patents filed from 1901 through 2010 at the USPTO. More importantly, it contains unique inventor (patentee) and assignee firm IDs for all patents, which can be used to trace which CEOs have been inventors and the firms under which their patents were filed. We follow a five-step process to match the inventors in this database to the CEOs in our ExecuComp sample.

In the first step we standardize the names in ExecuComp to conform with the format in the PID database. Second, we match each unique CEO name and company name in ExecuComp to the corresponding patentee and assignee name provided in the PID database and generate a list of possible matches. Third, when both a CEO's name and company reported in ExecuComp are an exact match to the patentee and assignee firm names in the PID, we designate such cases as probable matches. Fourth, to verify these probable matches and to identify the remaining cases where only a CEO's name is matched but not their company (because their patenting activity could have taken place at another firm), we collect biographies on all the matched CEOs in the sample from various sources including the Funding Universe website, Notable Names Data Base (NNDB), company websites, and other internet resources including Wikipedia, Forbes pages, Bloomberg's Business Week website, LinkedIn pages and Crunchbase.com. By tracking each CEO's career history, we can confirm whether they have worked for the assignee companies/organizations where they are identified as a patentee.[14] Fifth, when we are able to confirm that it is in fact a CEO in our dataset who has been awarded a patent, then we designate them as an "Inventor CEO".

To explore the effect of Inventor CEO heterogeneity we also construct several other Inventor CEO measures that reflect the nature of their inventor experience. We first distinguish Inventor CEOs with a history of high-impact patents. To do this, we use the forward citations data from KPSS to identify a set of high-impact patents, defined as those that receive an above median number of citations within their technology class-year. We then determine how many such high-impact patents are held by Inventor CEOs. Among our sample, the median Inventor CEO holds two high impact patents. Therefore, we designate a CEO as being a *High-Impact Inventor CEO* if they hold *more* than two such impactful patents. The remaining inventors are designated as *Low-impact Inventors CEOs.*[15] Panel D of Table 1 provides the breakdown of high and low-impact Inventor CEOs in each of our

[14] For example, Gilberto F. Amelio was the CEO for National Semiconductor Corp (1992-1995) and Apple Inc. (1996-1997). However, his inventor history in the PID shows 'Fairchild Camera and Instrument Corporation' as the assignee firm for all his patents applied for from 1973 through 1977. We track Amelio's career history and find that he had worked for Fairchild Camera and Instrument Corporation during 1971-1983 and so we are able to confirm him as an Inventor CEO.

[15] We require that a high-impact Inventor CEO has more than 2 high-impact patents to reduce the likelihood that their inventor success was due to chance. We adjust the citations on a patent technology class-year basis because some classes may have systematically higher citations and because of the mechanical relationship between patent citations and time.

sample years.

Our analysis of CEO patenting behavior also reveals a somewhat surprising fact. Half of the Inventor CEOs in our sample continue to be active inventors within their firms *during* their tenure. We designate a CEO to be an *Active Inventor CEO* for 2-years before to 2-years after a firm patent application is filed in their name, while they are CEO. We use 2-year pre- and post-windows above to account for the fact that a CEO can be involved in patent applications well before they are filed, and their inventing experience may remain relevant to the firm for a period after the filing. Panel E of Table 1 provides a breakdown of the number of active Inventor CEOs in each of our sample years.

2.3 Measuring innovation at the firm-level

We construct several measures of firm-level innovation. Following the extant literature, we use the natural logarithm of one plus the annual number of patents applied for (and subsequently granted) in each sample year as a proxy for the quantity of innovation (*Patents*). To measure the overall quality of innovation, we use the natural logarithm of one plus the number of forward citations received by these patents (*Citations*). To measure the *average* quality of innovation, we also use the natural logarithm of one plus the total number of forward looking citations for all patents filed by a firm in each sample year scaled by total number of patent applications filed by the firm in the same sample year (*Average Citations*). While patent citations indicate that a technology may have a scientific value, we are also interested in the economic value of a firm's innovation. To capture this, we use the market value of each patent as reported in the KPSS dataset. Specifically, we use the natural logarithm of one plus the average dollar value of all patents applied for during each sample year (*Patent Value*). Using a market value measure of patents also allows us to account for the effects of patent trolling.

Finally, we also wish to identify firms that spur radical or disruptive innovation. Thus, we construct a variable labelled, *Radical Innovation,* which is a dummy variable equal to one if any of a firm's patents are cited in the 99^{th} (or 90^{th}) percentile of the citation distribution within their technology class-year. A similar variable is used in Acemoglu, Akcigit, and Celik (2014) to distinguish incremental innovation from radical or disruptive innovation. To capture the quantity of radical innovation we also construct a continuous variable *#Radical Patents*, defined as the natural logarithm of one plus the number of a firm's patents cited in the 99^{th} (or 90^{th}) percentile of the citations distribution within their technology class-year.

2.4 Baseline control variables

We control for standard covariates in the innovation literature that explain corporate innovation and for which we have sufficient data coverage. We first use the natural logarithm of the book value of total assets to control for firm size.[16] R&D scaled by total assets is also used to account for differences in R&D spending across firms. It is important to distinguish any potential Inventor CEO effects from firm lifecycle effects. Thus, we control for firm age in all our specifications as this may affect both corporate innovation as well as the propensity to hire an Inventor CEO. Relatedly, we also control for the investment-intensity of a firm using total capital expenditure scaled by total assets. Since market value is highly correlated with the number of patent citations, we also control for the natural logarithm of Tobin's Q. Tobin's Q is estimated as the firm's market value of assets (debt plus equity market capitalization) scaled by the book value of total assets. The capital structure of R&D intensive firms customarily exhibits less leverage than other firms (Hall (2002)). To account for differences in financial risk between innovative and non-innovative firms, we control for leverage, measured as the sum of all long and short-term debt scaled by total assets.

A CEO's tenure can also potentially impact innovation, since firm-specific CEO experience might lead to more efficient innovation. We therefore control for the length (in

[16] Our results are robust to using the natural logarithm of total sales to measure firm size.

years) of a CEO's tenure. One might also argue that differences in CEO specific human capital may explain away the Inventor CEO effect. Thus, we control for whether a CEO holds an MBA[17] or possesses a technical education based on whether they hold an undergraduate or post-graduate degree in engineering, physics, operation research, chemistry, mathematics, biology or pharmacy. To control for a CEOs' specific expertise in the fields relevant to innovation, we follow Sunder et al. (2017) and create a separate indicator for CEOs who hold PhDs in STEM (Science, Technology, Engineering, and Mathematics).

We also control for an Inventor CEO's founder status. Any Inventor CEO effects may also be those generated by a founder (Lee, Kim and Bae (2016)). Since systematic data on founder CEOs is not freely available in standard datasets, we hand-collect all relevant information on founders for all the firms in our sample. Specifically, we collect data on the names and number of founders of each firm, as well as their founding year, from several sources including 10-K filings available in Electronic Data-Gathering, Analysis, and Retrieval (EDGAR), the Funding Universe website, company websites, and other internet resources including Wikipedia, Forbes pages, Bloomberg's Business Week website, among others. *Founder CEO* is then defined as a dummy variable that equals one if any sources explicitly mention that the current CEO is one of the original founders of the firm or was a main executive at the time the company was founded (see, Adams, Almeida and Ferreira (2009) and Fahlenbrach (2009)).

We also consider the possibility that the Inventor CEO indicator is picking up the difference between generalist and specialist CEOs. Custodio et al. (2017) construct a General Ability Index (GAI) that measures the extent to which an executive's life-time experience is specialized. We use this index to control for the confounding effect of industry-specific expertise on our results. A further confounding CEO characteristic that may be correlated

[17] We also consider CEOs' acquiring a finance education, defined as having a degree in accounting, finance, business (including MBA), or economics. We obtain similar results if we include this variable.

with both being an inventor and corporate innovation, is overconfidence (Hirshleifer et al. (2012), Galasso and Simcoe (2011)). Being an inventor may proxy for the same risk-taking predisposition associated with overconfident CEOs. Thus, to ensure that CEO overconfidence is not driving our results, we use the standard CEO overconfidence measure constructed by Hirshleifer et al. (2012). Table A1 details the construction and data sources of each of our variables. The final dataset for which we are able to obtain control variables for our baseline set of empirical specifications (excluding variables used for robustness) comprises of 4,621 firm-year observations for 543 unique high-tech firms.

2.5 Summary statistics

We report the distribution of Inventor CEOs by year, in Panel A of Table 1 and by Fama-French industry groups (that overlap with high-tech industries) in Panel B. We identify 150 unique Inventor CEOs in 134 unique firms. The percentage of Inventor CEOs ranges from 13.5% in 1993 to 23.2% in 2005. Many of the Inventor CEOs are in the medical equipment industry group followed by the electronic equipment industry. In panel C of Table 1, we report the cumulative number of patents granted to Inventor CEOs as at 2008. A total of 48 Inventor CEOs have been awarded a single patent grant, 19 have been awarded 2, while the rest have been awarded more than 2 patents. The maximum number of patents that a CEO has been awarded as a patentee in our sample is 222 by Steve Jobs of Apple Inc. Panels D and E of Table 1 provide a year by year break down of the proportion of *High-Impact Inventor CEOs* and *Active Inventor CEOs.* We note that across sample years there is an approximately equal proportion of high and low-impact inventors, and active and non-active inventors.

We provide descriptive statistics for the major variables used in this study in Table 2. We begin by comparing the sample means and medians of selected variables across the Inventor CEO and non-Inventor CEO groups. We find that firms with an Inventor CEO, on average, have 11.34 (25%) more patents and 112.56 (15.78%) more citations per firm-year observation compared to firms run by non-Inventor CEOs. Average citations per patent are also significantly higher for Inventor CEO-run firms compared to those run by non-Inventor CEOs (1.59 compared to 1.18). Inventor CEOs, on average, spend an additional 1.56 % of a firm's total assets on R&D relative to a sample mean of 8.72%, suggesting that they have a greater propensity to invest in innovation inputs that can spur innovation.

In relation to the remaining control variables, Inventor CEO-run firms are, on average, younger in age, use lower leverage and have higher market valuations. In terms of CEO characteristics, Inventor CEOs have, on average, a longer tenure, are more overconfident and are more likely to have a technical education (but less likely to have an MBA). We do not find any statistically significant differences in CEO age.

3 Baseline results

3.1 Inventor CEOs and firm-level innovation.

To establish a baseline correlation between Inventor CEOs and corporate innovation, we estimate the following OLS regressions:

$$Innovation_{i,t+1} = \alpha + \beta\ Inventor\ CEO_{i,t} + \gamma Z_{i,t} + Industry_k + Year_t + \varepsilon_{i,t} \quad (1)$$

The dependent variable, $Innovation_{i,t+1}$, is either *Patents*, *Citations*, *Patent Value, Average Citations* for firm *i* at time *t+1*. Since innovation may require significant time to produce patentable outcomes, we also examine the effect of Inventor CEOs on our innovation variables measured at time t+2 (unreported). *Z* is a vector of firm and CEO-level control variables described in previous section. Since the innovation performance of high-tech firms could be driven in part by common unobserved year and industry effects, we incorporate both year and industry-fixed effects in our models, where an industry is defined based on its

2-digit SIC code.[18] Standard errors are clustered at the firm level.

Table 3 reports the baseline findings. In models (1) through (4), no matter what measure of innovation is used, the coefficient of *Inventor CEO* is positive and statistically significant. Specifically, the Inventor CEO coefficient of 0.485 in model (1) suggests that firm years where an Inventor CEO is in charge are associated with a 35.3% greater patent output in the following year, relative to comparable non-Inventor CEO-led firms.[19] The co-efficient in model (2) indicates Inventor CEOs are associated with a 40.36% higher citation count. This suggests that Inventor CEO-run firms file patents that are of a higher quality. Further, these firms are also associated with approximately 16.67% higher average citations (model (3)) underscoring their impactful innovation. Not only do these patents appear to have scientific impact, but the results from model (4) indicate that patents filed by Inventor CEO-led firms are on average about $1.093 million more valuable. The unreported results for two-year ahead innovation measures also show a consistently strong association between Inventor CEOs and corporate innovation. In specifications (7) through (12) we also include additional control variables that may also explain the Inventor CEO effect. These are the presence of a founder CEO, a measure of CEO overconfidence and a measure of whether the CEO is a specialist or generalist in terms of their lifetime experience. Our results continue to hold even after controlling for these effects.

The sign and magnitude of other control variables are broadly consistent with the literature. For example, the coefficient on *R&D/Assets* is positive and significant in all the regressions. It is important to note that by controlling for innovation inputs (*R&D/Assets*) in our regressions, we can also infer that Inventor CEO-led firms have greater innovation efficiency. Larger firms (*Firm Size*) are associated with both a higher quantity and quality

[18] We also use industry-year fixed effects to account for innovation waves, and our results remain unchanged.

[19] Since dependent variables are one plus the natural logarithm of our innovation measures, economic magnitudes are calculated by taking the exponential of the relevant coefficient, subtracting 1 and comparing this to the respective variable mean.

of innovation. Firm leverage is negatively associated with corporate innovation, consistent with Hall (2002). We also find a positive coefficient on Tobin's Q, consistent with Lerner (1994).

3.2 Inventor CEO heterogeneity

In Table 4 we examine how Inventor CEO heterogeneity affects firm-level innovation. We first analyze how the quality of an Inventor-CEO's prior hands-on innovation experience (*High-Impact Inventor CEO* and *Low-Impact Inventor CEO)* affects innovation. In columns (1) through (3) we estimate the model on the full sample of firms to ascertain the impact of both high *and* low-impact Inventor CEOs relative to the omitted group (non-Inventor CEOs). The effect of Inventor CEOs is intensified when the firm is run by a high-impact inventor, with the economic magnitude of their respective coefficients being considerably larger than the base case (more than double). Low-impact inventors are also positively associated with our firm-level innovation measures, but both the statistical and economic significance of their respective coefficients is strikingly weaker. In column (12) we exclude active Inventor CEOs to ensure that we can establish an independent effect of high-impact inventors who are not active during their tenure. The results continue to hold, albeit with weaker statistical and economic significance.

In columns (6) through (8) we examine the effect of CEOs that remain active inventors during their tenure (*Active Inventor CEOs*) relative to all other CEOs in the sample. It is important to note that since there can be substantial within firm variation in whether an Inventor CEO is "active" across years, we can employ firm-fixed effects in these models. The results indicate that active Inventor CEOs also have a stronger economic association with firm-level innovation relative to the base case. The positive incremental impact of active Inventor CEOs continues to hold when we directly compare them to non-Active Inventor CEOs in columns (9) through (11). Overall these results illustrate that even within the

Inventor CEO sample, CEOs with stronger inventor credentials, and CEOs who are actively involved in their firm's innovation, tend to have an even stronger positive impact on corporate innovation.

3.3 Do Inventor CEOs spur radical innovation?

We next test whether Inventor CEOs are associated with radical or break-through innovations. We estimate the same specifications as our baseline models except the dependent variable is now *Radical Innovation* defined earlier. We report the results of a logit model of *Radical Innovation* in column (5) of Table 3 (baseline results) and column (4) of Table 4 (Inventor CEO heterogeneity results). The results in Table 3 show that Inventor CEO-run firms are associated with a higher probability of filing patents that are radical in nature. Table 4 shows that firms led by high-impact inventors are twice as likely to file ground breaking patents relative to the base case.

To capture the quantity of radical innovation being produced by a firm, we also use *#Radical Patents* as the dependent variable. The results, reported in column (6) in Table 3 and column (5) in Table 4, are consistent with those from the logit model: Inventor CEO-led firms are associated with a greater quantity of radical innovation and especially when their CEO has a personal history of high-impact patents.

3.4 Robustness tests

3.4.1. Alternative econometric models

In the innovation literature, Poisson and negative binomial empirical models are often employed due to the count-based nature of patent data (see Galasso and Simcoe (2011), Aghion, Van Reenen, and Zingales (2013)). We re-estimate our baseline models using these methods to ensure our results are not specific to any econometric estimation techniques. The unreported estimates show an even stronger economic and statistical relationship between

Inventor CEOs and corporate innovation.

We also re-estimate our baseline regressions using a set of propensity score matched control firms, as there may be insufficient overlap in the covariates we use to control for differences between Inventor and non-Inventor CEO firms. Using the variables in our baseline specifications (Tables 3 and 4) along with industry and year as matching variables, we obtain a set of counterfactual firms that (1) are from the exact same 2 digit SIC industry and (2) have an estimated propensity score that differs from the treated firms' propensity scores by no more than 10%. We then re-estimate the baseline models reported in Tables 3 and 4. The unreported results remain qualitatively unchanged: Inventor CEO-led firms show a strong positive association with corporate innovation.

3.4.2. Additional control variables

In other unreported regressions, we employ additional control variables that have also been shown to influence corporate innovation in the literature, but for which the coverage for our sample of firms is not complete. The first is a CEO's age. Young CEOs may have a greater propensity for "disruptive innovation" (see Acemoglu, Akcigit, and Celik (2014)). Our results are not sensitive to the inclusion of this characteristic. Second, long-term compensation has an important effect on innovation (Manso (2011)). To control for a CEO's long-term incentives, we use a CEOs' option delta and vega, as well as their level of stock ownership. Consistent with Lee at al. (2016) and Sunder et al. (2017) we find that the CEO vega measure is positively associated with the *Average Citations* variable. The coefficient on CEO delta however is not statistically significant. CEO ownership has a significantly negative correlation with innovation, suggesting that risk taking through innovation may be undesirable for a CEO when they are under-diversified. Importantly, the inclusion of these variables does not qualitatively change our findings.

Aspects of corporate governance also affect risk taking and therefore the incentives to innovate (Aghion et al. (2013) and Kim and Lu (2011)). To account for these factors we use the percentage of institutional holdings in a firm to proxy for the strength of external corporate governance and board co-option (independence) and board size, to proxy for the strength of internal governance. Our results are also robust to the inclusion of these variables.

3.5 Inventor CEO technology class experience

In this section we analyze whether an Inventor CEO's "learning-by-doing" advantage leads them to pursue innovation in technology classes related to their own inventor experience. If this is the case, then their technology class-specific inventor experience should be correlated with the technology classes under which their firms file new patents. Utilizing the patent filings data from PID, we trace which of the 430 possible technology classes an Inventor CEO files patents in, before becoming CEO of the focal firm. We next ascertain the distribution of each sample firm's registered patents across these same technology classes. In particular, for every firm-year we calculate the total number of new patents filed by the firm in each of the 430 technology classes. We then estimate the following OLS regression model to determine how a CEO's past technology class experience is related to the firm's patent outputs. The unit of observation in the model is a firm-year-technology class.

$$Patents\ in\ Class_{i,j,\ t+1} = \alpha + \beta_1\ Inventor\ CEO\ Class_{i,j,t-n} + Firm_i + Year_t + \varepsilon_{i,\ t} \quad (2)$$

The dependent variable, $Patents\ in\ Class_{i,j,\ t+1}$, is defined as the natural logarithm of one plus the number of firm *i*'s patents, filed in technology class *j*, in year *t+1*. The key explanatory variable is $Inventor\ CEO\ Class_{i,j,t-n}$ which is equal to one for firm-year-technology classes where a CEO has hands-on inventor experience in technology class *j* before becoming the CEO (at time *t-n*, where *n* is the number of years elapsed since the inventor became the firm's CEO) and zero otherwise. We also alternately employ two additional explanatory variables. The first is *High-Impact Class*$_{i,j,t-n}$ which is equal to one when an Inventor CEO has any high-impact patents in technology class *j* before becoming CEO. The second is *Class-Active Inventor CEO*$_{i,j,t}$ which is equal to one when an Inventor CEO has experience in technology class *j* before becoming CEO *and* is also an active inventor in technology *j* within two years around time *t*. In addition to all the baseline firm-level controls used in Table 3, we also control for a firm's *Patent Breadth*, defined as the number of technology classes in which a firm files patents in year *t+1*. Firms which invest in innovation across a large variety of classes may mechanically have a lower number of patents in each class.[20]

The results are reported Table 5. We estimate a variety of specifications that vary based on the level at which we impose fixed-effects. Model (1) imposes firm and year fixed effects. This specification pools together all firm-technology class observations for each sample firm. In doing so, it implicitly controls for all time invariant firm-specific factors that could explain firm innovation. The results indicate a significant positive correlation between the number of a firm's patents filed in a technology class and the CEO having hands-on experience in that same technology class. The size of the *Inventor-CEO Class* co-efficient indicates that an Inventor CEO with experience in a technology class is associated with a 22 percent average increase in the number of patents filed by the firm in that class. This is based on a mean of around 2.75 patents in each class, excluding classes with zero patents. The effect would be considerably stronger if we included classes with no patents when calculating the mean.

In model (2) we impose fixed effects at the firm-year level. By doing so we consider only cross-sectional variations in the patents filed by a firm across technology classes within each year. This specification controls for any firm-year specific effects (firm-level controls are automatically dropped). We find the results to be very similar to the firm fixed effects

[20] Our results are not sensitive to the inclusion of this variable.

specifications, implying that specific firm-year factors do not drive our results.

In models (3) through (6) we examine whether the above Inventor CEO effects vary based on the quality of the CEO's technology class-specific inventor experience (*High-Impact Class*), and on whether they are active inventors in the focal technology class during their tenure (*Class-Active Inventor CEO*). The effect of high-impact Inventor CEOs appears to be stronger than the base case. Firm-technology classes where the CEO has high-impact inventor experience are associated with a 15 percent greater patent output, relative to the baseline effect. Active Inventor CEOs have an even more pronounced effect on a firm's patent technology class distribution. Columns (5) and (6) show that technology classes where the CEO is both an active inventor and has inventor experience, are associated with a six-fold increase (after transforming coefficients) in the number of patents filed.

In an additional specification we impose the fixed effects at the firm technology class level. This particularly powerful specification implicitly controls for time invariant factors that explain a firm's propensity to innovate in a particular technology class (which is partly determined by a firm's inherent type). Our focus here is to examine whether the remaining time-variation in patent filings within a class, is related to the presence of an Inventor CEO with relevant class experience. To be estimated, this model requires there to be time-variation in Inventor CEO experience. By construction, the *Inventor CEO Class* variable is predetermined and does not change over time. Therefore, we use the time-varying *Class-Active Inventor CEO* variable as the primary explanatory variable in this model. The result is reported in column (7) of Table 5. The R-squared of this model is notably higher than the other models. Importantly, the positive and statistically significant coefficient of *Class-Active Inventor CEO* shows that even within a technology class, a firm files more patents in periods when its CEO has class relevant inventor experience *and* has an active first-hand involvement in the firm's innovation in the focal technology class.

In columns (8) through (11) we re-estimate the above models except on a sample of only Inventor CEO-led firms. This approach allows us to obtain point estimates that directly compare innovation outcomes across technology-classes where Inventor CEOs have experience against technology-classes (in the same firms) where they don't. The results are consistent with those estimated on the full sample, suggesting that the selection of CEOs to certain firm types that are inherently more innovative, is not necessarily driving our results.

While a firm may increase its patent output in classes related to their CEO's inventor experience, our results thus far do not establish the economic or scientific importance of such patents. Therefore, in Table 6 we examine whether a CEO's specific inventor experience increases the likelihood that a firm produces both economically valuable and scientifically important patents in technology classes where their experience lies. We define *Patent Class Value* as the natural logarithm of one plus the total value of all patents filed in technology class *j*, scaled by number of total number of patents filed in class *j*, in year *t+1*. We define an indicator variable *Radical Innovation (99)* (or *Radical Innovation (90)*) as being equal to 1 if any patents filed within the focal technology class-year are cited in the 99^{th} (or 90^{th}) percentile of the citations distribution and zero otherwise. The independent variables are the same as those in in Table 5, with one exception. We include the total number of patents filed by a firm in a technology class-year as an additional control, as a greater volume of patenting may mechanically increase the likelihood that a firm produces a patent that becomes highly cited.

The results in model (1) of Table 6 show that patents in technology classes where an Inventor CEO has experience are on average worth approximately $549,000 more than patents in classes where they do not. Models (2) through (4) show that this value is higher when Inventor CEOs have high impact experience and when they are active inventors. Columns (5) through (12) similarly suggest that the likelihood of a firm registering a radical patent in a class significantly increases when the CEO has in-class inventor experience. Models (4), (8) and (12) show that when *Class-Active Inventor CEOs* is used as the key explanatory variable the results are also robust to firm-technology class fixed effects.

4 Identification strategy

Whilst we believe that documenting the existence of a robust positive correlation between Inventor CEOs and corporate innovation is an important contribution of our paper, our empirical analysis thus far does not allow for a causal interpretation of the results. For instance, it is possible that highly innovative firms or firms with higher innovation potential hire Inventor CEOs. Inventor CEOs may also wish to join more innovative firms to exploit their potential. Thus, the relationship that we find could be explained through the assortative matching of Inventor CEOs to highly innovative firms.

To make any causal claims regarding the relationship between Inventor CEOs and corporate innovation would require a natural experiment that randomly assigns Inventor CEOs to firms and observes the outcome of interest. Unfortunately, this is not feasible in our setting. Thus, as a second-best alternative, we study situations when a CEO is replaced for plausibly exogenous reasons.[21] We utilize data from Eisfeldt and Kuhnen (2013) that classifies CEO turnovers during the period 1992-2006 as either being exogenous, forced or unclassified.[22] They identify a CEO turnover as exogenous if the CEO's departures was not forced and was announced at least six months before the anticipated succession date or was caused by a well-specified health problem. Typically, these departures are caused by health shocks. We do not use forced CEO turnovers and unclassified CEO turnovers since these events could be

[21] Studying CEO turnovers also keeps time invariant firm characteristics constant. Galasso and Simcoe (2011) and Sunder et al. (2017) examine the effect of CEO turnovers on corporate innovation, but do not distinguish whether a turnover is exogenous or not. This can be problematic because many CEO transitions can be related to the variable of interest. Bernile, Bhagwat, and Rau (2017) also use a similar approach to ours but implement it in a univariate setting.

[22] We thank Andrea Eisfeldt and Camelia Kuhnen for sharing their data on CEO turnovers. The data is available at: https://sites.google.com/site/andrealeisfeldt/.

endogenous with a firm's innovation.

Among this plausibly exogenous set of CEO turnovers, we identify a set of "treated" turnovers, defined as cases where an Inventor CEO is replaced with a non-Inventor CEO. We then carefully construct a control group of turnovers that are matched by time (year), 2-digit SIC industry, and firm size, and most importantly where a non-Inventor CEO is replaced by another non-Inventor CEO.[23] We exclude exogenous turnover events where an Inventor CEO is replaced by another Inventor CEOs or a non-Inventor CEOs is replaced by an Inventor CEO to ensure our regression estimates pertain only to the treatment.[24]

After merging our sample with the Eisfeldt and Kuhnen (2013) data we find 372 events of CEO changes of which 77 are exogenous CEO turnovers. Of these 77 exogenous CEO turnovers, 15 CEO turnovers involve a transition from an Inventor CEO to a non-Inventor CEO. From the remaining exogenous CEO turnovers, we find the corresponding matches following the matching criteria described above. This leads to total of 26 counterfactual firms. We retain data for firm-year observations from 3 years before until 3 years after each turnover event for both the treated and control firms.[25]

Equation (3) below sets out a difference-in-difference regression specification that analyzes the change in innovation outcomes around exogenous CEO turnovers in the treated group relative to the control group.

$$Innovation_{i,t+n} = \alpha + \beta\, Treated_{i,t} + \gamma\, CEO\ Turnover_{i,t} + \delta\, Treated * CEO\ Turnover + \varepsilon_{i,\,t} \quad (3)$$

Innovation is measured using the same set of proxies used in our earlier analysis

[23] A match must be within 15% of the size of the focal firm's total assets. Methodologically, our approach follows the CEO switching analysis in Galasso and Simcoe (2011), however we deviate in terms of event selection. Galasso and Simcoe (2011) use 28 cases of CEO switching, regardless of CEO change type (endogenous or plausibly exogenous).

[24] This setting also implicitly controls for any common turnover specific factors that could explain post-turnover changes in innovation.

[25] For some firms, we do not have the data for the full 6 years centered around the turnover date.

(number of patents, citations, value patents, radical innovation measures). We also report results here at t+2 to ensure that the longer-term effect of the turnover is captured. *Treated* is a dummy variable that takes the value 1 (both in pre- and post-turnover periods) if the firm has experienced a CEO transition from an Inventor CEO to a non-Inventor CEO or 0 otherwise (that is for our control firms). *CEO Turnover* is a dummy variable taking the value 1 in periods following an exogenous turnover and 0 for the pre-turnover period. The difference-in-difference coefficient *Treated*CEO Turnover* is of particular interest. A causal effect of Inventor CEOs on corporate innovation would manifest in a negative coefficient on this interaction term, since an exogenous change from an Inventor CEO to a non-Inventor CEO should cause a decline in innovation outputs.

We control for any potentially confounding factors that are driven by unobservable time invariant firm-level characteristics by employing firm-fixed effects. We also account for other firm and CEO characteristics that could change around a CEO turnover by including all the control variables used in Table 3. For instance, a CEO transition could involve a founder departing the firm. Similarly, the firm may also be undergoing fundamental changes, which are captured by controlling for firm size, leverage, R&D to total assets, CAPEX to total assets and Tobin's Q.

We report the results of the regressions in Table 7. The post-exogenous CEO turnover co-efficient *CEO Turnover*, indicates that for control firms, corporate innovation outputs increase following a CEO's exogenous departure.[26] However, we find that the interaction term *Treated*CEO Turnover* is negative and statistically significant. The magnitude of this co-efficient, based on most of the alternate dependent variables, is significantly larger than the *CEO Turnover* coefficient, indicating that, on average, corporate innovation output decreases in an absolute sense (not just relative to control firms) following an exogenous transition

[26] This result is consistent with Bereskin and Hsu (2013) who find that new CEOs stimulate greater innovation.

from an Inventor CEO to a non-Inventor CEO. Models (6) and (7) show that the propensity to generate radical innovation also shows a marked relative decline in the post turnover period for the treated firms.

We next examine how an exogenous CEO turnover affects the technology class distribution of patents filed by a firm. To do this, we estimate a similar difference-in-difference specification to equation (3) above, except that the unit of observation is a firm technology class-year, similar to our earlier technology class analysis. In this setting, "treated" and "control" observations take on slightly different meanings. Treated observations are now firm-technology classes in which the Inventor CEO has hands-on experience, and control observations are classes where they do not.

One important feature of this empirical setting is that we can restrict the analysis to only Inventor CEO-led firms, so that technology classes within these firms where the Inventor CEO does not have experience, can serve as the control group of observations. Such an approach deals with any potential biases arising from an inability to find an appropriate set of control firms. For example, Inventor CEOs could be strictly selected into specific firm types for which there are no appropriate counterfactuals in the economy.

We report the results from estimating models on a sample of only Inventor CEO-led firms in columns (8) through (11) of Table 7. The dependent variables in these models are either *Patents in Class*, defined earlier or *#Radical Class Patents (99)* and *#Radical Class Patents (90)* defined as the natural logarithm of one plus the number of patents that are cited in the 99^{th} or 90^{th} percentile of the citations distribution of patents in a focal technology class-year respectively. We use these dependent variables rather than the *Radical Innovation* indicator, because their greater variation makes them more suitable dependent variables for estimating models among the smaller sample of firms we examine here.

We include all our baseline controls in these empirical models and impose fixed effects at the firm technology class level, so that we only consider year-to-year variations in patents filed within each firm-technology class and how this is influenced by a change in an Inventor CEO's class experience. The difference-in-difference coefficient (*Treated*CEO Turnover*) indicates that when an Inventor CEO exogenously departs a firm, there is a significant reduction in the number, value and impact of patents filed in technology classes where their hands-on experience lies. The *CEO Turnover* coefficient indicates that in the "control" technology classes (within Inventor CEO firms), there is no notable change in the number and impact of patents. In unreported robustness tests, we also expand the set of counterfactual technology classes to include classes in the matched non-Inventor CEO control firms used earlier. The results remain unchanged. The results also hold when we remove firm-technology class observations for which no patents are filed.

Our empirical strategy relies on two key identifying assumptions. First, the timing of Inventor CEO departures should be random and thus should not systematically coincide with changes in firm innovation. Second, the choice of an Inventor CEO's successor should also be exogenous to a firm's time-varying innovation potential. The first assumption is satisfied by focusing only on plausibly exogenous CEO departures. Regarding the second assumption, it is important to highlight that our approach cannot definitively rule out the possibility that the CEO succession choice is influenced by a firm's innovation profile. However, we provide preliminary evidence that one plausible driver of the decision to replace an Inventor CEO who departs exogenously, with a non-Inventor CEO, is the short-supply of Inventor CEOs in the labor market, which is exogenous to an individual firm's innovation.

The supply of Inventor CEOs is likely to be restricted by the fact that these individuals need to possess both inventor experience and outstanding executive capabilities that make them a viable CEO candidate. If such CEOs are in short supply, then this should be reflected in the price of their services. In an unreported analysis we examine whether this is the case by comparing the compensation of Inventor and non-Inventor CEOs. To do this we collect information on the total compensation (cash, stock and options) of all CEOs in our sample, and test if Inventor CEOs earn a premium, after controlling for an extensive set of firm and CEO characteristics. We find that Inventor CEOs receive significantly higher compensation, consistent with the notion that their unique skillset is in short supply.

5 Value creation by Inventor CEOs

While we have provided evidence suggesting a causal link between Inventor CEOs and corporate innovation, this need not be value enhancing for all firms. Inventor CEOs could be overinvesting in innovation. For example, some studies have documented dissatisfaction with corporate venture capital programs because CEO's make risky investments in early stage innovative projects that do not generate sufficient risk-adjusted returns for shareholders (Gompers and Lerner (2000)). Further, active Inventor CEOs may become distracted from other important aspects of their executive role, and this also may be value reducing. Another dimension of this problem is that active Inventor CEOs could use corporate resources to pursue "inventing" as an activity from which they derive private utility, but that could be value destroying for shareholders.

We estimate a simple OLS regression model, where Tobin's Q is the dependent variable, and test whether Inventor CEOs generate greater market value for shareholders. We find that Inventor CEOs are associated with higher market valuations. The results are even stronger for active Inventor CEOs. To make stronger causal claims about this result we examine the valuation consequences of an exogenous transition from an Inventor to a non-Inventor CEO, using the same set of turnovers from the previous section. The results in column (5) of Table 8 are in line with the aggregate correlation from the broader sample.

6 How do Inventor CEOs facilitate successful innovation?

6.1 Evaluating and selecting innovative investment projects

Our evidence thus far suggests that Inventor CEOs spur greater and more valuable innovation, especially in technology classes related to their experience. In this section, we further analyze whether Inventor CEOs are more able to successfully identify and evaluate innovation-intensive investment opportunities. To do this, we study the corporate acquisitions decisions (and their outcomes) of the firms in our sample. Corporate acquisitions are among the largest investment decisions made by a firm and importantly, possess many observable characteristics that make it possible to study differences in the investment decisions of Inventor and non-Inventor CEOs.

In a competitive M&A market, difference in the information set of bidders can create a winner's curse problem (see Thaler (1988), Barberis and Thaler, (2003), Baker et al. (2007)). This problem can deter relatively uninformed parties from bidding for targets due to the risk of overpayment. This risk will be most pronounced for deals involving target firms that are harder to value (i.e. where being uninformed presents a significant disadvantage). Our arguments so far suggest that because of their hands-on experience, Inventor CEOs should be more informed about the true value of innovation-intensive investment projects or firms. Therefore, in equilibrium, other less informed bidders, fearing the winners curse, should stay away from competing with Inventor CEOs on such targets. Equivalently, Inventor CEOs should target these firms to exploit their information advantage. The existence of such an advantage leads to two key empirical predictions. First, Inventor CEO-run firms should be more likely to acquire innovation-intensive firms with higher information asymmetry. Second, when Inventor CEOs acquire such targets, their firms should attract significantly higher acquirer announcements returns, due to both their ability to identify high quality innovative target firms and the lack of competition from other bidders.

We test these predictions by assembling a set of acquisitions made by our sample firms from the SDC database from 1992-2008. In terms of deal selection, we follow the standard criteria to select our sample of deals (see Masulis, Wang and Xie (2007)). Specifically, we require i) all acquisitions to be completed, ii) the acquirer controls less than 50% of the shares prior to the announcement and owns 100% of the target's shares after the transaction, ii) the deal value is more than $1 million and at least 1% of the acquirer's market value of equity (measured on the 11th trading day prior to the announcement date), and iv) the acquirer has annual financial statement information available from Compustat and stock return data from CRSP. We also limit our sample to deals only involving a target firm in a high-tech industry because we are interested in how Inventor CEOs exploit their information advantage to make investment decisions related to the current scope of their operations (rather than the decision to diversify out of high-tech).[27]

Testing our first empirical prediction requires us to distinguish deals where the target can be considered innovation-intensive. To do this, we collect information on the number of patents filed by each target firm in the sample. Among all targets firms in the sample, we find that approximately one-third hold registered patents while the remaining firms do not. This provides a simple criterion upon which to distinguish innovation-intensive from non-innovation-intensive target firms. To test whether Inventor CEOs have a higher propensity to buy innovation-intensive targets, we employ a logistic regression where the dependent variable is an indicator variable which takes the value 1 if the target firm in an M&A deal has received at least one patent. Our empirical models also control for the same set of CEO and firm characteristics in our previous analysis, as well as additional deal-level factors that could potentially explain our results, such as relative deal size, whether the target is public

[27] The results hold even without imposing this restriction.

or private and whether the deal is in the same 2-digit SIC as the acquirer. The results in Table 9, column (1) show that the Inventor CEO indicator variable is positive and statistically significant, suggesting that Inventor CEOs have a higher likelihood of acquiring innovative firms, relative to non-Inventor CEOs.

To further determine the extent to which Inventor CEOs exploit their information advantage, we examine their propensity to acquire firms that are both innovative *and* private. These firms should have higher information asymmetry since they are not subject to public disclosure requirements and can be particularly difficult to value, given the absence of an established market price. We argue that under such circumstances Inventor CEOs should have an even greater information advantage. Column (2) of Table 9 provides the results from an empirical model where the dependent variable is an indicator that takes the value 1 if the target in an M&A deal is *both* private and innovation-intensive. The results show that the likelihood that an Inventor CEO acquires such firms is slightly higher than the base case. This is consistent with their advantage becoming even more pronounced when an innovative firm's information asymmetry is large.

In columns (3) through (6) in Table 9, we investigate whether the propensity to acquire private and innovative targets varies based on the quality of an Inventor CEO's experience and on whether they are an active inventor. The results in columns (3) and (4) show that Inventor CEOs with high quality experience have an even higher propensity to acquire private and innovative targets and appear to be driving the baseline results. Columns (5) and (6) show that active Inventor CEOs are also much more likely to acquire private and innovative targets relative to non-active and non-Inventor CEOs.

The decision to acquire private and innovation-intensive targets can be risky for shareholders given the information asymmetry surrounding such deals. However, an Inventor CEO's superior deal selection ability may alleviate these problems and ensure such acquisitions are value enhancing for shareholders.[28] Further, the value accretive nature of such acquisitions may be amplified by the fact that competing bidders stay away from competing on such deals with Inventor CEOs due to the winner's curse. To test these arguments, we calculate the 5-day cumulative abnormal returns (CARs) around the acquisition dates in our sample. We find that acquiring firms led by an Inventor CEO experience significantly higher acquisition announcement returns. The *Inventor CEO* coefficient in model (1) of Panel A in Table 10 shows that Inventor CEOs are associated with a 1.2 percentage point larger M&A announcement return. The unreported control variables used in this model are identical to Table 9. The remaining columns in Panel A examine whether announcement returns are larger when the innovation intensity and information asymmetry of the target firm are particularly high. Column (2) shows that when examining only private and innovative targets, the acquirer announcement returns on deals announced by Inventor CEOs approximately double to 2.7 percent compared to the base case. The economic magnitude of this effect is quite significant given that the average announcement return in our sample is 0.17%.

In Panel B of Table 10 we split Inventor CEOs into two categories based on their impact. Our results show that the positive announcement returns for Inventor CEOs is driven by high-impact inventors. In terms of magnitude, the effect is strongest for high-impact Inventor CEOs who buy private and innovative targets (model (2)), although the statistical significance is marginal. In Panel C, we examine whether acquisition announcement returns vary based on whether the Inventor CEO is active. The magnitude of the acquisition returns for active Inventor CEOs is approximately double that of all Inventor CEOs reported in Panel A. The higher announcement returns for active Inventor CEOs reach a peak of 4.6 percentage points also in model (2). Overall, these results show that Inventor CEOs rationally

[28] An alternative interpretation of this result is that Inventor CEOs may also be better able to integrate the technologies of both the acquirer and target.

target firms where their "learning-by-doing" information advantage lies, and when they do, they achieve higher announcement returns.

6.2 Executing innovative investment projects

For many high-tech firms their ability to successfully execute innovative investment projects is ultimately judged by the market's response to their products. To assess whether Inventor CEOs can more successfully execute innovative investment projects, we study stock market reactions to their firm's product announcements. To do this, we use data on new product announcement returns provided by Mukherjee, Singh and Zaldokas (2017).[29] They combine textual analysis with event studies on stock market returns to construct new product announcement returns. By estimating cumulative abnormal returns over a three-day period around a firm's product announcements, they are able to estimate i) the total incremental value of all new product introductions for each firm in each calendar year (the sum of all positive cumulative abnormal returns) and, ii) the total number of "major" product announcements defined as those with cumulative abnormal returns above the 75th percentile in the distribution. We use these two measures as dependent variables to assess the perceived success of new products launched by Inventor CEO-led firms.

Column (1) in Table 11 shows that Inventor CEO-run firms enjoy a 0.198 percentage point greater market value increase from new product announcements relative to other CEOs. In column (2), we show that compared to low-impact Inventor CEOs, high-impact Inventor CEOs have a stronger statistical association with new product announcements returns, although the economic magnitude of the effect is weaker compared to low-impact Inventor CEOs.[30] Column (3) shows that product announcements made by active Inventor CEOs attract slightly higher announcement returns compared to the base case. In column (4) we

[29] We thank Abhiroop Mukherjee for making this data available at https://sites.google.com/site/abhiroopmukherjee/

[30] This is likely due to the outliers in returns, a problem which we address by using an alternative dependent variable in models (5) through (8).

remove active inventors from the sample so that we can purely observe the effect of the CEO's past inventor experience. In these tests the effect of low impact inventors becomes statistically insignificant.

Columns (5) through (8) of Table 11 estimate the same specifications except using the natural logarithm of one plus the number of major new product announcements as the dependent variable. The results are largely consistent with the announcement returns tests. Importantly, the results in columns (6) and (8) show that in this setting, the effect of high impact inventors is both economically and statistically stronger than low-impact inventors.

7 Conclusion

In this paper we study whether a CEO's hands-on innovation experience as an inventor, endows them with unique capabilities in spurring innovation at the firms they lead. At the baseline, we show that firms led by Inventor CEOs are associated with a greater volume of registered patents, more valuable and highly cited patents, higher innovation efficiency, and a greater propensity to produce ground-breaking or disruptive innovations. Such superior innovation outcomes are also reflected in higher market valuations for Inventor-CEO-led firms.

Among the sample of Inventor CEOs, the specific nature of their hands-on experience also explains variations in corporate innovation. We show that CEOs with high impact inventor experience, as well as CEOs who maintain first-hand involvement in their firm's innovation, have an incrementally positive effect on their firm's patent output and impact. The specific technology classes in which an Inventor CEO possesses hands-on experience also matter. Firms produce more patents and patents of higher scientific impact and economic value in technology classes where their CEO has hands-on inventor experience.

To determine whether the above effects are causal, we study exogenous CEO turnovers. Firms exogenously switching from Inventor to non-Inventor CEOs experience a significant decline in corporate innovation. These turnovers also lead to a change in the technology class distribution of a firm's newly filed patents. Following the departure of an Inventor CEO fewer and less impactful patents are filed in technology classes in which the outgoing CEO has hands-on inventor experience.

Finally, our analysis of the channels through which Inventor CEOs promote higher quality innovation is consistent with their hands-on inventor experience better equipping them to evaluate, select and execute innovation-intensive investment projects. Using the M&A market as a laboratory, we show that Inventor CEOs tend to acquire other innovative high-tech firms with high information asymmetry and that such acquisitions earn significantly positive announcement returns. Inventor CEOs also tend to make more breakthrough product announcements that, on average, create greater shareholder wealth compared with products launched by non-Inventor CEO-led firms. Overall, our results paint a consistent picture of the unique innovation-enhancing capabilities that CEOs with hands-on experience "doing" innovation bring to their firms.

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Table 1. Sample distribution of Inventor CEOs

This table provides a breakdown of the number of Inventor CEOs, non-Inventor CEOs and the percentages of Inventor CEOs by year and by industry groups. (excludes financials and regulated utilities).

Panel A: Sample distribution by year

Year	non-Inventor CEOs	Inventor CEOs	Inventor CEOs (%)
1992	146	23	13.6%
1993	166	26	13.5%
1994	168	31	15.6%
1995	186	37	16.6%
1996	200	37	15.6%
1997	225	48	17.6%
1998	233	57	19.7%
1999	223	61	21.5%
2000	236	60	20.3%
2001	251	58	18.8%
2002	261	57	17.9%
2003	255	64	20.1%
2004	239	61	20.3%
2005	208	63	23.2%
2006	231	55	19.2%
2007	266	66	19.9%
2008	262	61	18.9%
Total	3,756	865	18.7%

Panel B: Sample distribution of Inventor CEO firm-year observations by Fama-French 12 Industry groups

Industry	Non- Inventor CEOs	Inventor CEOs	Inventor CEOs (%)
Medical Equipment	250	132	34.6%
Communication	325	19	5.5%
Business Services	970	106	9.9%
Computers	597	121	16.9%
Electronic Equipment	1,204	395	24.7%
Measuring and Control	410	92	18.3%
Total	3,756	865	18.7%

Panel C: Distribution of cumulative number of patents granted to Inventor CEOs

Cumulative # of Patents up to 2008	# of CEOs
1	48
2	19
>2	83
Total	150

Panel D: High Impact Inventor CEOs among the Inventor-CEOs sample

Year	Inventor CEO Patent Impact		% of High Impact Inventor CEOs
	Low	High	
1992	14	9	39.1%
1993	16	10	38.5%
1994	18	13	41.9%
1995	22	15	40.5%
1996	24	13	35.1%
1997	29	19	39.6%
1998	34	23	40.4%
1999	38	23	37.7%
2000	31	29	48.3%
2001	32	26	44.8%
2002	29	28	49.1%
2003	33	31	48.4%
2004	33	28	45.9%
2005	33	30	47.6%
2006	29	26	47.3%
2007	32	34	51.5%
2008	28	33	54.1%
Total	475	390	45.1%

Panel E: Active Inventor CEOs among the Inventor CEO sample

Year	Active Inventor CEOs		% of Active Inventor CEOs
	No	Yes	
1992	9	14	60.9%
1993	8	18	69.2%
1994	13	18	58.1%
1995	18	19	51.4%
1996	19	18	48.6%
1997	24	24	50.0%
1998	23	34	59.6%
1999	21	34	61.8%
2000	23	37	61.7%
2001	21	37	63.8%
2002	23	34	59.6%
2003	33	31	48.4%
2004	30	31	50.8%
2005	35	28	44.4%
2006	34	21	38.2%
2007	44	22	33.3%
2008	44	17	27.9%
Total	428	437	50.5%

Table 2. Summary statistics

This table presents summary statistics for select variables used in this study. T-test (Wilcoxon-Mann-Whitney tests) are conducted to test for differences between the means (medians) for firm-year observations with and without Inventor CEOs. Variable definitions are provided in Appendix A1. *,**,*** denote significance level at the 10%, 5%, and 1% level, respectively.

Variables	**non-Inventor CEOs**				**Inventor CEOs**			
	N	Mean	Median	Std. Dev	N	Mean	Median	Std. Dev
Dependent variables								
Number of Patents	3756	45.18	2.00	169.84	865	56.53*	8.00***	170.98
Number of Citations	3756	600.39	8.00	2640.12	865	712.97*	57.00***	2455.31
Patents	3756	1.63	1.10	1.83	865	2.31***	2.08***	1.77
Patents (t+2)	3586	1.58	0.69	1.85	835	2.16***	1.95***	1.84
Citation	3756	2.55	1.61	2.80	865	3.54***	3.58***	2.70
Citations (t+2)	3559	2.39	1.10	2.78	808	3.19***	3.07***	2.74
Average Citations	3756	1.18	0.57	1.35	865	1.59***	1.51***	1.32
Dollar value of patents (yearly sum in millions)	3756	634.88	6.64	2409.92	865	1062.27***	32.21***	3507.97
Patent Value	3756	2.69	2.03	2.85	865	3.67***	3.50***	2.70
#Radical Patents	3756	0.21	0.00	0.55	865	0.32***	0.00***	0.64
Radical Innovation	3756	0.17	0.00	0.38	865	0.26***	0.00***	0.438
Other variables								
Overconfident CEO (67)	3328	0.31	0.00	0.46	808	0.36***	0.00***	0.48
CEO Age	3634	53.15	53.00	7.74	845	53.10	53.00	8.46
CEO Tenure	3756	7.82	6.00	6.92	865	12.03***	10.00***	8.85
Founder-CEO	3756	0.21	0.00	0.41	865	0.54***	1.00***	0.50
PhD (STEM)	3756	0.08	0.00	0.28	865	0.29***	0.00***	0.46
Technical Education	3756	0.57	1.00	0.49	865	0.71***	1.0***	0.45
MBA	3756	0.32	0.0	0.47	865	0.21***	0.0***	0.41
No School Information	3756	.09	0.0	0.29	865	0.10	0.0	0.31
Firm Size	3756	6.62	6.39	1.69	865	6.29***	6.02***	1.64
RD/Assets	3756	0.08	0.07	0.08	865	0.10***	0.09***	0.07
CAPEX	3756	0.05	0.04	0.05	865	0.06***	0.04**	0.05
Firm Age	3756	2.48	2.56	0.88	865	2.37***	2.48***	0.79
Leverage	3756	0.13	0.04	0.17	865	0.10***	0.01***	0.15
Tobin's Q	3756	0.79	0.69	0.59	865	0.90***	0.82***	0.63

Table 3: Inventor CEOs and innovation outputs

The table reports the estimates from several regression models examining the relationship between Inventor CEOs and corporate innovation. The dependent variables are *Patents,* defined as log (1+#of new patents applied for at time (t+1)), *Citations* defined as log (1+# of citations attributable to patents applied for at time (t+1)), *Average Citations* is defined as log (1+ *Citations/Patents* at time (t+1)), *Patent Value* is the log (1+average value of patents applied for at time (t+1)) as computed in Kogan et al. (2017), *#Radical Patents* defined as log(1+# of patents applied for at (t+1) that are cited in the 99^{th} percentile of the technology-class-year citations distribution) and *Radical Innovation* is an indicator variable equal to one if *#Radical Patents* is greater than zero. *Inventor CEO* is equal to one if the CEO has at least one patent registered in her own name. *Firm Size* is the natural logarithm of the book value of a firm's total assets. *Firm-age* is the natural log of a firm's age since incorporation. *CAPEX* is capital expenditure scaled by total assets. *R&D/Assets* is research and development expenditures scaled by total assets. *Leverage* is long-term debt plus short-term debt scaled by total assets. *Tobin's Q* is defined as the log of the book value of debt plus the market value of equity scaled by the book value of total assets. *CEO Tenure* is the CEO tenure in years. *PhD (STEM)* is an indicator variable equal to one for CEOs with a PhD in Science, Technology, Engineering and Mathematics and zero otherwise. *Technical Education* is an indicator variable equal to one for CEOs with an undergraduate or graduate degree in engineering, physics, operation research, chemistry, mathematics, biology, pharmacy, or other applied science and zero otherwise. *MBA* is an indicator variable equal to one if the CEO received MBA degree or zero otherwise. *No school information* is an indicator equal to one if we cannot identify the CEOs' undergraduate school and zero otherwise. Columns (7) - (12) examine the effect of additional control variables. These are *Founder CEO* equal to one if the CEO is a founder of the firm or CEO since the founding year of the firm, the *General Ability Index* (GAI) which is an index that measures the diversity of CEO's career experiences, as defined in Custodio et al. (2013) and *Overconfident CEO (67)* which is an indicator variable equal to one for all years after the CEO's options exceed 67% moneyness and zero otherwise, as defined in Hirshleifer et al. (2012). All regressions include year and industry (based on two digit SIC code) fixed effects. Standard errors are clustered at the firm level. *t*- ratios are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Patents	Citations	Average Citations	Patent Value	Radical Innovation (Logit)	#Radical Patents	Patents	Citations	Patents	Citations	Patents	Citations
Inventor CEO	0.485***	0.741***	0.319***	0.739***	0.571***	0.097*	0.457***	0.717***	0.460***	0.636***	0.420***	0.636***
	(4.153)	(4.425)	(4.271)	(4.915)	(2.727)	(1.830)	(3.797)	(4.118)	(3.300)	(3.295)	(3.660)	(3.884)
Firm-size	0.677***	0.836***	0.197***	1.196***	0.885***	0.171***	0.678***	0.837***	0.774***	0.908***	0.754***	0.905***
	(16.027)	(15.887)	(9.460)	(21.917)	(14.704)	(8.224)	(16.067)	(15.917)	(14.788)	(14.103)	(16.961)	(16.877)
RD/Assets	4.266***	5.841***	2.180***	6.001***	5.466***	0.766***	4.303***	5.873***	6.249***	8.171***	4.519***	5.981***
	(6.752)	(6.317)	(5.106)	(6.775)	(4.846)	(4.129)	(6.802)	(6.349)	(6.653)	(6.479)	(7.120)	(6.478)
CAPEX	2.998***	3.936***	0.602	2.575**	1.295	0.743	2.988***	3.928***	3.323***	4.119***	3.125***	3.698***
	(3.078)	(2.942)	(1.105)	(2.114)	(0.769)	(1.359)	(3.062)	(2.934)	(2.768)	(2.599)	(3.010)	(2.597)
Firm-Age	0.107*	0.046	-0.069*	0.106	0.198**	0.044*	0.123*	0.060	0.126	0.120	0.110	0.066
	(1.734)	(0.541)	(-1.867)	(1.137)	(1.971)	(1.941)	(1.957)	(0.687)	(1.549)	(1.103)	(1.602)	(0.715)
Leverage	-0.742***	-0.983***	-0.297	-1.396***	-1.125**	-0.270***	-0.740***	-0.981***	-0.757**	-0.758	-0.907***	-1.098***
	(-2.954)	(-2.638)	(-1.621)	(-3.823)	(-2.068)	(-2.979)	(-2.943)	(-2.633)	(-2.262)	(-1.567)	(-3.326)	(-2.729)

Tobin's Q	0.242***	0.357***	0.130***	0.791***	0.543***	0.099***	0.233***	0.350***	0.265***	0.433***	0.247***	0.361***
	(3.488)	(3.654)	(2.959)	(8.098)	(3.979)	(3.191)	(3.329)	(3.546)	(3.069)	(3.635)	(3.401)	(3.529)
CEO Tenure	-0.008	-0.008	-0.000	-0.016**	-0.016	-0.003*	-0.013**	-0.013	-0.006	-0.007	-0.005	-0.006
	(-1.553)	(-1.119)	(-0.027)	(-2.125)	(-1.616)	(-1.906)	(-2.262)	(-1.463)	(-0.981)	(-0.799)	(-0.862)	(-0.763)
PhD (STEM)	0.178	0.110	-0.037	0.339*	0.081	0.048	0.166	0.100	0.326**	0.311	0.181	0.111
	(1.295)	(0.549)	(-0.399)	(1.865)	(0.367)	(0.803)	(1.207)	(0.500)	(2.273)	(1.591)	(1.301)	(0.550)
Technical Education	0.023	0.148	0.131**	0.142	0.178	-0.040	0.031	0.155	0.046	0.154	0.148	0.294**
	(0.223)	(1.024)	(2.050)	(0.965)	(0.991)	(-0.915)	(0.302)	(1.072)	(0.366)	(0.879)	(1.415)	(1.979)
MBA	-0.011	0.007	0.024	0.095	0.149	-0.022	0.003	0.019	0.058	0.103	-0.006	-0.050
	(-0.116)	(0.050)	(0.351)	(0.692)	(0.870)	(-0.597)	(0.032)	(0.133)	(0.515)	(0.620)	(-0.061)	(-0.341)
No school information	-0.122	-0.201	-0.062	-0.069	-0.174	-0.045	-0.100	-0.182	-0.010	-0.055	-0.066	-0.206
	(-0.895)	(-0.928)	(-0.539)	(-0.334)	(-0.460)	(-0.928)	(-0.732)	(-0.834)	(-0.047)	(-0.181)	(-0.458)	(-0.901)
Founder CEO							0.164	0.141				
							(1.364)	(0.750)				
General Ability Index (GAI)									-0.022	-0.037		
									(-0.443)	(-0.562)		
Overconfident CEO (67)											-0.110	-0.076
											(-1.072)	(-0.512)
Observations	4,621	4,621	4,621	4,621	4,621	4,621	4,621	4,621	3,189	3,189	4,136	4,136
Adjusted R-squared	0.561	0.540	0.457	0.597	N/A	0.304	0.562	0.541	0.583	0.568	0.589	0.568
Year fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Table 4. Inventor CEO heterogeneity and firm innovation outputs

The table reports the estimates from several regression models examining the relationship between Inventor CEO heterogeneity and corporate innovation. Th dependent variables are *Patents,* defined as log (1+#of new patents applied for at time (t+1)), *Citations* defined as log (1+# of citations attributable to patents applied for at time (t+1)), *Patent Value* is the log (1+average value of patents applied for at time (t+1)) as computed in Kogan et al. (2017), #Radical Patents defined as log(1+# of patents applied for at (t+1) that are cited in the 99th percentile of the technology class-year citations distribution) and *Radical Innovation* is an indicator variable equal to one if #Radical Patents is greater than zero. *High-Impact Inventor CEO* is equal to one if the CEO holds more than two patents which register an above median number of technology class-year adjusted citations. *Low-Impact Inventor CEO* is equal to one if the number of patents registered to the CEO that accumulate an above median number of technology class-year adjusted citations is less than or equal to 2. *Active Inventor CEO* is equal to one if the CEO has at least one patent issued in her own name around 2 years of focal firm year. All regressions include year and industry (based on two digit SIC code) fixed effects, except for models (6)-(8) which use firm fixed effects. Baseline controls are included in the models (not reported). Standard errors are clustered at the firm level. *t*- ratios are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Full sample					Full sample			Inventor CEO sample			Excluding Active Inventor CEOs
Variables	Patents	Citations	Patent Value	Radical Innovation (Logit)	#Radical Patents	Patents	Citations	Patent Value	Patents	Citations	Patent Value	Patents
High-impact Inventor CEO	0.818***	1.290***	1.154***	1.246***	0.193***							0.396*
	(6.199)	(6.360)	(6.567)	(4.467)	(3.181)							(1.842)
Low-impact Inventor CEO	0.246*	0.349*	0.440**	0.051	0.029							-0.024
	(1.731)	(1.824)	(2.530)	(0.193)	(0.418)							(-0.146)
Active Inventor CEO						0.265***	0.610***	0.364***	0.699***	1.214***	0.931***	
						(2.701)	(3.903)	(2.728)	(4.626)	(5.328)	(5.395)	
Baseline controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	4,621	4,621	4,621	4,621	4,621	4,621	4,621	4,621	865	865	865	4,184
Adjusted R-squared	0.565	0.545	0.599	N/A	0.308	0.856	0.802	0.854	0.606	0.621	0.716	0.556
Year fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y
Firm fixed effects	N	N	N	N	N	Y	Y	Y	N	N	N	N

Table 5: The effect of an Inventor CEO's patenting experience on a firm's patent technology class distribution

The table reports the estimates from regression models examining the relationship between an Inventor CEO's technology class experience and the firm's technology class distribution of patents. The dependent variable is *Patents in Class* defined as the natural logarithm of one plus the total number of patents that have been applied for by the firm in the focal technology class. *Inventor CEO Class* is an indicator variable that takes the value of 1 if the CEO has patenting experience in the focal technology class before becoming the CEO of the focal firm. *High-impact Class* is an indicator variable that takes the value of 1 if the CEO has high-impact patenting experience in the focal technology class before becoming the CEO of the focal firm. *Class-active Inventor CEO* is an indicator variable that takes the value of 1 if the CEO has patenting experience in the focal technology class before becoming the CEO of the focal firm *and* is an active inventor in that class during their tenure. Regression specifications include year, firm, firm-year, technology class-year or firm-technology class fixed effects as indicated. Baseline control variables and *Patent Breadth* (defined as the unique number of patent classes that the firm has registered patents in that year) are included in the models, but suppressed in the table. Standard errors are clustered at the level of fixed effects. *t*- ratios are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Patents in Class										
	Full Sample							Inventor CEO Sample			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Inventor CEO Class	0.475***	0.479***						0.478***			
	(6.856)	(18.551)						(6.848)			
High-impact Class			0.533***	0.536***					0.535***		
			(6.739)	(18.615)					(6.709)		
Class-active Inventor CEO					1.586***	1.590***	0.516***			1.588***	0.565***
					(14.944)	(32.221)	(7.534)			(14.958)	(7.106)
Baseline controls	Y	N	Y	N	Y	N	Y	Y	Y	Y	Y
Observations	1,423,268	1,423,268	1,423,268	1,423,268	1,423,268	1,423,268	1,423,268	266,420	266,420	266,420	266,420
Adjusted R-squared	0.109	0.108	0.109	0.108	0.122	0.123	0.695	0.098	0.096	0.122	0.747
Year fixed effects	Y	N	Y	N	Y	N	Y	Y	Y	Y	Y
Firm fixed effects	Y	N	Y	N	Y	N	N	Y	Y	Y	N
Firm*year fixed effects	N	Y	N	Y	N	Y	N	N	N	N	N
Firm*technology class fixed effects	N	N	N	N	N	N	Y	N	N	N	Y

Table 6: The average value of patents and radical innovation for Inventor CEOs with class-relevant experience

The table reports the estimates from several regression models examining the relationship between an Inventor CEO's technology class experience and the firm's patents. The dependent variables are *Patent Class Value* defined as log (1+average value of patents in a technology class) as estimated in Kogan et al. (2017), *Radical Innovation 99th* or *Radical Innovation 90th* defined as an indicator variable taking the value of one if patents registered by the focal firm within a technology class in a year has been cited in the 99th (90th) percentile of the citations distribution of a technology class-year. *Inventor CEO Class* is an indicator variable that takes the value of 1 if the CEO has patenting experience in the focal technology class before becoming the CEO of the focal firm. *High-impact Class* is an indicator variable that takes the value of 1 if the CEO has high-impact patenting experience in the focal technology class before becoming the CEO of the focal firm. *Class-active Inventor CEO* is an indicator variable that takes the value of 1 if the CEO has patenting experience in the focal technology class before becoming the CEO of the focal firm *and* is an active inventor in that class during their tenure. Regression specifications include year, firm, and firm-technology class fixed effects as indicated. Baseline control variables and an additional control for the number of patents that the firm has filed in the focal technology class in that year, are included in the models, but suppressed in the table. Standard errors are clustered at the level of fixed effects. *t*- ratios are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Patent Class Value				*Radical Innovation (99)*				*Radical Innovation (90)*			
Inventor CEO Class	0.438***				0.018**				0.117***			
	(7.294)				(2.321)				(6.619)			
High-impact Class		0.473***				0.019**				0.127***		
		(7.403)				(2.257)				(6.646)		
Class-active Inventor CEO			1.296***	0.926***			0.091***	0.048*			0.418***	0.235***
			(9.724)	(8.140)			(3.129)	(1.804)			(9.640)	(5.121)
Baseline controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	266,420	266,420	266,420	266,420	266,420	266,420	266,420	266,420	266,420	266,420	266,420	266,420
Adjusted R-squared	0.207	0.206	0.212	0.558	0.196	0.196	0.201	0.241	0.247	0.246	0.261	0.445
Year fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm fixed effects	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	N
Firm*technology class fixed effects	N	N	N	Y	N	N	N	Y	N	N	N	Y

Table 7: Exogenous CEO turnovers

The table presents the results for our exogenous CEO turnover analysis. The dependent variables are *Patents,* defined as log (1+#of new patents applied for at time (t+1)) or at (t+2) for *Patens (t+2)*, *Citations* defined as log (1+# of citations attributable to patents applied for at time (t+1)) or at (t+2) for *Citations (t+2)*, *Average Citations* is defined as log (1+ *Patents/Citations* at time (t+1)), *Patent Value* is the log (1+average value of patents applied for at time (t+1)) as computed in Kogan et al. (2017), *#Radical Patents (99)* and *#Radical Patents (90)* are defined as log(1+# of patents applied for at (t+1) that are cited in the 99th (or 90th) percentile of the technology class-year citations distribution) *Patents in Class is* defined as the natural logarithm of one plus the total number of patents that have been applied for by the firm in the focal technology class at t+1. *Patent Class Value* is defined as log (1+average value of patents in the focal technology class at t+1) as estimated in Kogan et al. (2017). *#Radical Class Patents (99)* and *#Radical Class Patents (90)* are defined as log(1+# of patents in the focal technology class that are cited in the 99th (or 90th) percentile of the technology class-year citations distribution). *CEO Turnover* is an indicator for an exogenous CEO departure as defined in Eisfeldt and Kuhnen (2013). In columns (1) through (7), *Treated* is an indicator variable taking the value 1 if an exogenous CEO turnover involves a transition from an Inventor CEO to non-Inventor CEO and 0 otherwise. In columns (8) through (10), we estimate models using the sample of Inventor CEO firm technology class-years. *Treated* here represents a treated firm-technology class. This is an indicator variable taking the value 1 if an exogenous CEO turnover involves a transition from an Inventor CEO with patenting experience in a focal technology class to a non-Inventor CEO and 0 otherwise. Regression specifications include year, firm, or firm-technology class fixed effects as indicated. Baseline control variables and patent breadth (defined as the unique number of patent classes that the firm has registered patents in that year) are included in the models, but suppressed in the table. Standard errors are clustered at the firm level for models (1) through (7) and at the firm-technology class level in models (8) though (11). *t*- ratios are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively

	Firm-year level analysis							Firm-year-technology class level analysis			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Variables	Patents	Patents (t+2)	Citations	Citations (t+2)	Value of patents	#Radical Patents (99)	#Radical Patents (90)	Patents in Class	Patent Class Value	#Radical Class Patents (99)	#Radical Class Patents (90)
CEO Turnover	0.306**	0.332***	0.246	0.102	0.243	0.033	0.280**	0.006	0.007	-0.001	0.003
	(2.457)	(2.861)	(0.715)	(0.371)	(1.285)	(0.308)	(2.365)	(1.144)	(0.666)	(-0.741)	(1.158)
Treated*CEO Turnover	-0.439***	-0.573***	-0.612*	-0.623**	-0.563***	-0.224	-0.276**	-0.034***	-0.047***	-0.004*	-0.021***
	(-3.016)	(-4.352)	(-1.669)	(-2.138)	(-3.086)	(-1.466)	(-2.394)	(-4.430)	(-3.146)	(-1.702)	(-4.275)
Baseline controls	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	233	230	233	230	233	233	233	13,244	13,244	13,244	13,244
Adjusted R-squared	0.282	0.304	0.536	0.505	0.296	0.201	0.219	0.802	0.627	0.284	0.596
Year fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm fixed effects	Y	Y	Y	Y	Y	Y	Y	N	N	N	N
Firm*technology class fixed effects	N	N	N	N	N	N	N	Y	Y	Y	Y

Table 8: Inventor CEOs and value creation

The table presents regression estimates from a model of examining the relationship between Inventor CEO and firm value. The dependent variable is *Tobin's Q* is defined as the log of the book value of debt plus the market value of equity scaled by the book value of total assets. *Inventor CEOs* is equal to one if the CEO has at least one patent issued in her own name. *High-Impact Inventor CEO* is equal to one if the CEO holds more than two patents which register an above median number of technology class-year adjusted citations. *Low-Impact Inventor CEO* is equal to one if the number of patents registered to the CEO that accumulate an above median number of technology class-year adjusted citations is less than or equal to 2. *Active Inventor CEO* is equal to one if the CEO has at least one patent issued in her own name around 2 years of focal firm year. *CEO Turnover* is an indicator for an exogenous CEO departure as defined in Eisfeldt and Kuhnen (2013). *Treated* is an indicator variable taking the value 1 if an exogenous CEO turnover involves a transition from an Inventor CEO to non-Inventor CEO and 0 otherwise. All regressions include year and either 2 digit SIC based industry or firm fixed effects as indicated. Baseline controls are included in the models but are suppressed in the table. Standard errors are clustered at the firm level. t- ratios are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)
	Tobin's Q				
Inventor CEO	0.120***				
	(2.785)				
High-impact Inventor CEO		0.126**			
		(2.264)			
Low-impact Inventor CEO		0.114**			
		(2.309)			
Active Inventor CEO			0.096**	0.128***	
			(1.976)	(2.596)	
Treated*CEO turnover					-0.257**
					(-2.237)
CEO turnover					0.099
					(0.987)
Baseline controls	Y	Y	Y	Y	Y
Observations	4,621	4,621	4,621	4,621	230
Adjusted R-squared	0.592	0.421	0.592	0.592	0.535
Year fixed effects	Y	Y	Y	Y	Y
Industry fixed effects	Y	N	Y	N	N
Firm fixed effects	N	Y	N	Y	Y

Table 9: Inventor CEO M&A target firm selection

The table presents estimates from logit regressions examining target selection in M&As made by the Inventor-CEOs. The two dependent variables are defined as follows. *Innovative Target* is an Indicator variable that equals one if the target has received patents in the past. *Private & Innovative Target* is an indicator variable equal to one if the target of the M&A deal is a private firm and has received patents in the past. *Inventor CEO* is equal to one if the CEO has at least one patent issued in her own name from US Patent and Trademark office (USPTO). *High-Impact Inventor CEO* is equal to one if the CEO holds more than two patents which register an above median number of technology class-year adjusted citations. *Low-Impact Inventor CEO* is equal to one if the number of patents registered to the CEO that accumulate an above median number of technology class-year adjusted citations is less than or equal to 2. *Active Inventor CEO* is equal to one if the CEO has at least one patent issued in her own name around 2 years of focal firm year. *Cash/Assets* is total cash and cash equivalents scaled by total assets. *Diversifying Deal Indicator* is an indicator variable that equals one if the target and acquirer differ in their Fama-French-12 industries (FF12) classification. *Relative Deal Size* is the ratio of the deal value to the market capitalization of the bidder. *Public Target* is an indicator variable that equals one if the target in an M&A deal is a public firm. Baseline controls are included in the models but are suppressed in the table. All regressions include year and industry (based on two digit SIC code) fixed effects. Standard errors are clustered at the firm level. t- ratios are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Innovative Target	Private & Innovative Target	Innovative Target	Private & Innovative Target	Innovative Target	Private & Innovative Target
Inventor CEO	0.344**	0.374**				
	(1.988)	(2.446)				
High-impact Inventor CEO			0.781***	0.537***		
			(4.729)	(3.507)		
Low-impact Inventor CEO			0.048	0.264*		
			(0.272)	(1.763)		
Active Inventor CEO					0.367**	0.469**
					(1.967)	(1.980)
Cash/Assets	-0.513*	0.250	-0.511*	0.199	-0.530*	0.238
	(-1.858)	(0.631)	(-1.899)	(0.614)	(-1.847)	(0.597)
Diversifying Deal Indicator	0.891*	0.675**	0.874*	0.468	0.916*	0.690**
	(1.749)	(2.136)	(1.716)	(1.259)	(1.823)	(2.227)
Relative Deal Size	0.384***	-0.549***	0.378***	0.104***	0.381***	-0.552***
	(12.960)	(-8.010)	(12.295)	(2.756)	(13.208)	(-7.709)
Public Target	0.642***		0.643***		0.638***	
	(7.051)		(7.211)		(7.229)	
Baseline controls	Y	Y	Y	Y	Y	Y
Observations	1,418	1,383	1,418	1,383	1,418	1,383

Industry fixed effects	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y	Y

Table 10. M&A Cumulative Abnormal Announcement Returns

The table presents regression estimates from a model examining the relationship between Inventor CEO-led firms and the cumulative abnormal stock price returns (CARs) from acquisition announcements. The dependent variable is the five-day cumulative abnormal returns calculated using the market model. The market model parameters are estimated over the period (−210, −11) using CRSP equally-weighted return market data. Column (1) estimates the model using all M&As in the sample. Column (2) estimates the model using only deals involving target firms that are private & innovative, defined as targets that are not publicly listed and that have received at least one patent in the past. Column (3) estimates the model using only deals whether the target is neither private, nor innovative. *Inventor CEO* is equal to one if the CEO has at least one patent issued in her own name from the US Patent and Trademark office (USPTO). *High-Impact Inventor CEO* is equal to one if the CEO holds more than two patents which register an above median number of technology class-year adjusted citations. *Low-Impact Inventor CEO* is equal to one if the number of patents registered to the CEO that accumulate an above median number of technology class-year adjusted citations is less than or equal to 2. *Active Inventor CEO* is equal to one if the CEO has at least one patent issued in her own name around 2 years of focal firm year. All regressions include year and acquirer industry interacted joint fixed effects. Baseline control variables and deal level control variables are the same as in Table 9, but are suppressed in this table. Standard errors are clustered at the firm level. t- ratios are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	(1)	(2)	(3)
		CAR (-2, +2)	
Panel A: Inventor CEOs & M&A announcement returns			
	All M&A	Private & Innovative Target	Non-Private or Non-innovative target
Inventor CEO	0.012***	0.027**	0.010
	(3.588)	(2.490)	(1.647)
Deal level controls	Y	Y	Y
Baseline controls	Y	Y	Y
Observations	1,418	244	1,174
Adjusted R-squared	0.116	0.311	0.123
Year*industry fixed effects	Y	Y	Y
Panel B: High- and Low- Impact Inventor CEOs & M&A announcement returns			
High-impact Inventor CEO	0.014*	0.038*	0.009
	(1.745)	(1.971)	(0.854)
Low-impact Inventor CEO	0.011**	0.020	0.010*
	(2.104)	(1.615)	(1.773)
Deal level controls	Y	Y	Y
Baseline controls	Y	Y	Y
Observations	1,418	244	1,174
Adjusted R-squared	0.116	0.313	0.123
Year*industry fixed effects	Y	Y	Y

Panel C: Active Inventor CEOs & M&A announcement returns			
Active Inventor CEO	0.026***	0.046**	0.023**
	(3.408)	(2.375)	(2.258)
Deal level controls	Y	Y	Y
Baseline controls	Y	Y	Y
Observations	1,418	244	1,174
Adjusted R-squared	0.120	0.322	0.125
Year*industry fixed effects	Y	Y	Y

Table 11: Inventor CEO new product announcement

The table presents regression estimates from a model examining the relationship between Inventor CEO-led firms and new product announcements. The dependent variables are *New Product Announcement Returns* defined as the sum of all positive cumulative abnormal returns around new product announcements over the year and *Major New Product Announcements* defined as the log *(1+#Major New Product Announcements)* where *#Major New Product Announcements* is the number of product announcements with cumulative abnormal returns above the 75^{th} percentile of announcement return distribution. Both variables are obtained from Mukherjee et al. (2017). *Inventor CEO* is equal to one if the CEO has at least one patent issued in her own name from the US Patent and Trademark office (USPTO). *High-Impact Inventor CEO* is equal to one if the CEO holds more than two patents which register an above median number of technology class-year adjusted citations. *Low-Impact Inventor CEO* is equal to one if the number of patents registered to the CEO that accumulate an above median number of technology class-year adjusted citations is less than or equal to 2. *Active Inventor CEO* is equal to one if the CEO has at least one patent issued in her own name around 2 years of focal firm year. All regressions include year and industry (based on two digit SIC code) fixed effects. Baseline controls are included in the models but suppressed in the table. Standard errors are clustered at the firm level. t- ratios are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Full sample			Excluding Active Inventor CEOs	Full sample			Excluding Active Inventor CEOs
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	New Product Announcement Returns				Major New Product Announcements			
Inventor CEO	0.198**				0.295***			
	(2.352)				(2.887)			
High-impact Inventor CEO		0.164***		0.109**		0.350***		0.294**
		(2.760)		(1.982)		(3.003)		(2.061)
Low-impact Inventor CEO		0.221*		0.188		0.258**		0.230*
		(1.969)		(1.588)		(2.060)		(1.729)
Active Inventor CEO			0.212**				0.357***	
			(2.532)				(3.212)	
Baseline controls	Y	Y	Y	Y	Y	Y	Y	Y
Observations	1,438	1,438	1,438	1,348	1,438	1,438	1,438	1,348
Adjusted R-squared	0.338	0.328	0.339	0.333	0.364	0.363	0.365	0.348
Industry fixed effects	Y	Y	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y	Y	Y	Y

Table A1. Variable definitions

Innovation Variables	
Patents	The natural logarithm of one plus the number of patents filed in year t+1. Source: KPSS (2017)
Patents (t+2)	The natural logarithm of one plus the number of patents filed in year t+2.Source: KPSS (2017)
Citations	The natural logarithm of one plus the number of citations attributable to patents applied for at time t+1. Source: KPSS (2017)
Citations (t+2)	The natural logarithm of one plus the number of citations attributable to patents applied for at time t+2. Source: KPSS (2017)
Average Citations	The natural logarithm of one plus the total number of forward looking *Citations* for all patents registered in t+1 scaled by total number of patents registered in year t+1. Source: KPSS (2017)
Dollar Value of Patents	Dollar value of patents as estimated using equation (3) in Kogan et al. (2017) on the 3-day window following the patent issue date and deflated to 1982(million) dollar using the CPI. 3-day return is computed as the cumulative market adjusted return over the three-day period from Tuesday to Thursday. (Patents are always issued on Tuesdays). Source: KPSS (2017)
Patent Value	The natural logarithm of one plus the average dollar value of patents applied for by a firm at time (t+1)). Source: KPSS (2017)
#Radical Patents	The natural logarithm of one plus # of patents applied for at (t+1) that are cited in the 99^{th} percentile of the technology-class-year citations distribution. Source: KPSS (2017)
Radical Innovation	Indicator variable equal to one if #Radical Patents is greater than zero. Source: KPSS (2017)
Patents in Class	The natural logarithm of one plus the total number of patents that have been applied for by the firm in the focal technology class in a year). Source: KPSS (2017)
Patent Class Value	The natural logarithm of one plus the average dollar value of all patents applied for by the firm in the focal technology class in a year. Source: KPSS (2017)
Radical Innovation 99^{th}	Indicator variable taking the value of one if patents registered by the focal firm within a technology class in a year have been cited in the 99th percentile of the citations distribution of a technology-class-year. Source: KPSS (2017)
Radical Innovation 90^{th}	Indicator variable taking the value of one if patents registered by the focal firm within a technology class in a year have been cited in the 90th percentile of the citations distribution of a technology-class-year. Source: KPSS (2017)
# Radical class Patents (99)	The natural logarithm of one plus # of patents applied for at (t+1) by the focal firm within a technology class in a year that are cited in the 99th percentile of the citations distribution of a technology-class-year. Source: KPSS (2017)
# Radical class Patents (90)	The natural logarithm of one plus # of patents applied for at (t+1) by the focal firm within a technology class in a year that are cited in the 90th percentile of the citations distribution of a technology-class-year. Source: KPSS (2017)

Inventor CEO Variables	
Inventor CEO	Indicator variable equal to one if the CEO has at least one patent registered in her own name. Source: PID (Li et al. (2014)) and other internet sources including the Funding Universe website, Notable Names Data Base (NNDB), company websites, Wikipedia, Forbes pages, Bloomberg's Business Week website, LinkedIn pages and Crunchbase.com.
High-Impact Inventor CEO	Indicator variable equal to one if the CEO holds more than two patents which register an above median number of technology-class-year adjusted citations. Source: Source: PID (Li et al. (2014)) and KPSS (2017) and other internet sources as above.
Low-Impact Inventor CEO	Indicator variable equal to one if the number of patents registered to the CEO that accumulate an above median number of technology-class-year adjusted citations is less than or equal to 2. Source: PID (Li et al. (2014)) and KPSS (2017) and other internet sources as above.
Active Inventor CEO	Indicator variable equal to one if the CEO has at least one patent issued in her own name around 2 years of focal firm year. Source: PID (Li et al. (2014)) and other internet sources as above.
Inventor CEO Class	Indicator variable that takes the value of one if the CEO has patenting experience in the focal technology class before becoming the CEO of the focal firm. Source: PID (Li et al. (2014)) and KPSS (2017) and other internet sources as above.
High-impact Class	Indicator variable that takes the value of one if the CEO has high-impact patenting experience in the focal technology class before becoming the CEO of the focal firm. Source: PID (Li et al. (2014)) and KPSS (2017)) and other internet sources as above.
Class-active Inventor CEO	Indicator variable that takes the value of one if the CEO has patenting experience in the focal technology class before becoming the CEO of the focal firm *and* is an active inventor in that class during their tenure. Source: PID (Li et a. (2014)) and other internet sources as above.
Firm Characteristics Variables	
Firm Size	The natural logarithm of the book value of a firm's total assets. Source: Compustat
Firm-age	The natural logarithm of a firm's age since incorporation. Sources: CRSP
CAPEX	Capital expenditure scaled by total assets. Sources: Compustat
R&D/Assets	Research and development expenditures scaled by total assets. Sources: Compustat
Leverage	Long-term debt plus short-term debt scaled by total assets. Source: Compustat
Tobin's Q	The natural logarithm of the book value of debt plus the market value of equity scaled by the book value of total assets. Source: Compustat
Cash/Assets	Total cash and cash equivalents scaled by total assets. Source: Compustat
Patent breadth	The unique number of patent classes that the firm has registered patents in a year. Source: KPSS (2017)

CEO Characteristics	
CEO Tenure	CEO tenure in years. Source: ExecuComp
CEO Age	CEO age in years. Source: ExecuComp
PhD (STEM)	Indicator variable equal to one for CEOs with a PhD in Science, Technology, Engineering and Mathematics and zero otherwise. Source: hand-collected from several sources including company websites and other internet resources including Wikipedia and Bloomberg's Business Week website.
Technical Education	Indicator variable equal to one for CEOs with an undergraduate or graduate degree in engineering, physics, operation research, chemistry, mathematics, biology, pharmacy, or other applied science and zero otherwise. Source: hand-collected from several internet resources as above.
MBA	Indicator variable equal to one if the CEO received MBA degree or zero otherwise. Source: hand-collected from several internet resources as above.
No school information	Indicator variable equal to one if we cannot identify the CEOs' undergraduate school and zero otherwise. Source: hand-collected from several internet resources as above.
Founder CEO	Indicator variable equal to one if the CEO is a founder of the firm or CEO since the founding year of the firm. Source: hand-collected from several sources including 10-K filings from the SEC available through Electronic Data-Gathering, Analysis, and Retrieval (EDGAR), the Funding Universe website, company websites, and other Internet resources including Wikipedia, Forbes pages, Bloomberg's Business Week website, among others.
General Ability Index (GAI)	An index that measures the diversity of CEO's career experiences, as defined in Custodio et al. (2013). Source: Website of Claudio Custodio: https://sites.google.com/site/claudiapcustodio/research
Overconfident CEO (67)	Indicator variable equal to one for all years after the CEO's options exceed 67% moneyness and zero otherwise, as defined in Hirshleifer et al. (2012). Specifically, we obtain the total value per option of the in-the-money options by dividing the value of all unexercised exercisable options by the number of options (ExecuComp item: opt_unex_exer_est_val / Opt_unex_exer_num). Next, we divide this value per option by the price at the end of the fiscal years (Compustat item: prcc_f). Source: ExecuComp & Compustat
M&A deal characteristics	
Innovative Target	Indicator variable that equals one if the target has received patents in the past. Source: SDC Platinum and PID (Li et al. (2014))
Private & Innovative Target	Indicator variable equal to one if the target of the M&A deal is a private firm and has received patents in the past. Source: SDC Platinum and PID (Li et al. (2014))
Diversifying Deal Indicator	Indicator variable that equals one if the target and acquirer are in a different Fama-French-12 industries (FF12) classification. Source: SDC Platinum
Relative Deal Size	The ratio of the deal value to the market capitalization of the bidder. Source: SDC Platinum
Public Target	Indicator variable that equals one if the target in an M&A deal is a public firm. Source: SDC Platinum

CAR (-2, +2)	Five-day cumulative abnormal returns calculated using the market model. The market model parameters are estimated over the period (−210, −11) using CRSP equally-weighted return market data. Source: CRSP
New Product Announcement related variables	
New Product Announcement Return	The sum of all positive cumulative abnormal returns around new product announcements over the year. Mukherjee et al. (2017) implement event-study methodology by fitting a market model over (−246,−30) period to get the expected returns on the firm's stock, and then estimate cumulative abnormal returns (CARs) over 3 (−1,1) day period around the announcement of new products. Source: Mukherjee et al. (2017)
Major New Product Announcements	the natural logarithm of one plus the *#Major New Product Announcements* where #Major New Product Announcements is the number of product announcements with cumulative abnormal returns above the 75th percentile of announcement return distribution. Source: Mukherjee et al. (2017)