Are Founder CEOs Better Innovators?

Evidence from S&P 500 Firms

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ABSTRACT

Using a novel dataset on founder CEOs in S&P 500 firms for the period from 1993 to 2003, this paper investigates the relationship between founder CEOs and innovation. While entrepreneurs as individuals have long been considered change agents, whether entrepreneurs as managers of organizations may facilitate organizations' innovation performance is not obvious. Our main results show that the existence of a founder CEO is correlated with a 31 percent increase in the citation-weighted patent count before we control for R&D spending and a 23 percent increase in the citation-weighted patent count after we control for R&D spending, suggesting that founder CEOs are more effective and efficient innovators than professional CEOs. We find that the positive effect of founder CEOs on innovation is stronger in more competitive industries. In addition, we find that founder CEOs exert positive and significant effects on raw patent counts, citations per issued patent, and R&D intensity. Furthermore, our results suggest that founder CEOs are more likely to take their firms in a new technological direction. Our findings are particularly convincing since the results are consistent across various robustness checks that control for potential selection issues and other endogeneity concerns (e.g., firm fixed effects regressions, propensity score matching method, innovation trend analyses around a CEO switch event).

Keywords: founder CEOs; innovation; R&D; entrepreneurship; behavioral strategy

"Innovation distinguishes between a leader and a follower"

- Steve Jobs, Founder CEO of Apple -

INTRODUCTION

In the management and economics literature, innovation has been often described as the fundamental role of entrepreneurs. In his seminal study, Schumpeter (1934) views the entrepreneur as the agent who discovers opportunities, initiates change, and actualizes unattempted endeavors. Ever since, innovation has been the focus of many entrepreneurial theories and has driven much of the literature to focus on entrepreneurs' role in bringing technological and environmental innovation to the world (e.g., Drucker, 2002; Shane & Venkataraman, 2000). To validate theoretical arguments related to entrepreneurs, empirical studies have predicted and identified that entrepreneurial venture firms can be better innovators than incumbent firms in industries (e.g., Agarwal, Echambadi, Franco, & Sarkar, 2004; Christensen, 2013; Christensen & Bower, 1996; Tripsas, 1997) depending on the external conditions (e.g., market competition, market uncertainty) and their organizational characteristics (e.g., complementary assets, market share, organizational inertia, rigidities of core capabilities, disincentives for innovation).

However, surprisingly, we still lack a clear understanding of the effects of arguably the most important building block of entrepreneurship, i.e., founder CEOs, on innovation. That is, previous studies have not systematically studied the relationship between the founder as a manager in a firm and its innovation performance. Although founders, who are entrepreneurs by definition, are viewed as the individuals who are consistently pursuing new combinations of knowledge (Wasserman, 2012), whether founders as managers of established companies are better innovators than professional CEOs who are trained to possess better managerial skills is not obvious. As their entrepreneurial venture grows, founder CEOs are often replaced by professional CEOs, who

substantially differ from founder CEOs (e.g., Boeker & Karichalil, 2002; Wasserman, 2012). These replacements by professional CEOs may drive different innovation strategy that may, in turn, differently affect firms' innovation performance. Hence, we attempt to answer following research questions in this study: Are founder CEOs able to generate innovation more effectively and/or efficiently than professional CEOs? While previous empirical studies have mostly focused on the relationship between founder CEOs and their financial performance (e.g., Adams, Almeida, & Ferreira, 2009; Fahlenbrach, 2009; Jayaraman, Khorana, Nelling, & Covin, 2000; Villalonga & Amit, 2006), there has been relatively few, if any, systematic studies that examine the relationship between founder CEOs and innovation performance in large established companies. In this study, we attempt to fill this research gap by studying the relationship between the existence of a founder CEO in a firm and the firm's innovation performance using various innovation measures (e.g., citation-weighted patent count, raw patents, citation per patents, R&D intensity).

Theoretical arguments from the founder CEO literature provide two conflicting predictions. On the one hand, studies focusing on founder CEO's entrepreneurial characteristics (e.g., Knight, 1921; Shane & Venkataraman, 2000) suggest that founder CEOs are better innovators than professional CEOs. This stream of literature posits that founder CEOs are more likely to be risk takers (e.g., Camerer & Lovallo, 1999; Kihlstrom & Laffont, 1979) and that they are more likely to pursue growth than professional CEOs (e.g., Miller, Breton-Miller, & Lester, 2011; Shane & Venkataraman, 2000). Hence, founder CEO-managed firms will generate more innovations than professional CEO-managed firms. On the other hand, studies drawing on corporate lifecycle theory (e.g., Boeker & Karichalil, 2002; Boeker & Wiltbank, 2005) argue that founder CEOs engender worse or, at best, the same innovation performance as professional CEOs. The corporate life cycle literature suggests that as their firm grows to a certain stage, founder CEOs may lack efficient

organization managing skills to inspire innovation (e.g., Boeker & Wiltbank, 2005; Wasserman, 2012). Furthermore, founder CEOs are required to transition in their role from entrepreneur to manager and, in turn, to become similar to professional CEOs (e.g., Boeker & Karichalil, 2002; Jain & Tabak, 2008; Tushman, Virany, & Romanelli, 1985). Hence, founder CEO-managed firms will generate less innovation than professional CEO-managed firms or will not significantly differ from professional-CEO managed firms with respect to innovation performance.

To test these conflicting predictions, we combine standard measures of innovation, based on U.S. patent data, with financial and accounting data on S&P 500 firms for the period from 1993 to 2003. Specifically, we consider the role of founder CEOs of large publicly traded companies to rule out any potential confounding effects that may arise from comparing new venture firms with large established firms. We run panel data regressions on a sample of 1,456 firms and 2,354 CEOs, of which 333 are founders and 2,031 are professional CEOs, for a total of 8,856 firm-year observations. Our sample consists of large public firms from various industries, excluding financial and utilities industries. Our main results show that the existence of a founder CEO is correlated with a 31 percent increase in the citation-weighted patent count (i.e., forward citations received by patents filed in a given year) before we control for R&D spending and a 23 percent increase in the citation-weighted patent count (i.e., forward citations received by patents filed in a given year) after we control for R&D spending, suggesting that founder CEOs are more effective *and* efficient innovators than professional CEOs. We find that the positive effect of founder CEOs on innovation is stronger in more competitive industries. Our results are particularly convincing since our results are consistent across various robustness checks that control for potential selection issues and other endogeneity concerns (e.g., firm fixed effects regressions, propensity score matching method, innovation trend analyses around a CEO switch event). To provide a more

nuanced understanding of our results, we consider several additional outcome variables and find that founder CEOs exert positive and significant effects on raw patent counts (i.e., number of patents filed in a given year), citations per issued patent, and R&D intensity.

Furthermore, we extend our baseline results in several ways. First, we examine the link between founder CEOs and two measures of innovative direction (i.e., patent diversity and breakthrough patents). The results suggest that the existence of a founder CEO leads firms to pursue explorative and radical innovations. Second, we show that the interaction between founder CEOs and innovation performance measured as the citation-weighted patent count has a positive and significant effect on firms' financial performance, which provides evidence that the innovations of founder CEO-managed firms create more financial value than the innovations of professional CEO-managed firms. This finding strengthens our preferred interpretation of the main results by showing that founder CEOs are not merely overinvesting in risky projects for valueless innovations.

Our study provides several important contributions to the literature on founder CEO, innovation and corporate governance. First, we contribute to the founder CEO literature in particular and the entrepreneurship literature in general by linking founders' entrepreneurial characteristics with technological innovation. Our study provides strong evidence for the old but somewhat underexplored conjecture that entrepreneurs, as founder CEOs, are the change agents of the status quo and that their existence in firms is significantly related to innovation (e.g., Drucker, 2002; Knight, 1921; Schumpeter, 1934). Furthermore, we complement the founder CEO literature by providing a potential explanation for why founder CEO-managed firms enjoy higher market performance than professional CEO-managed firms (Adams et al., 2009; Fahlenbrach, 2009; Villalonga & Amit, 2006). Previous studies have found that the market values innovative activities

(Hall, 1999). Specifically, everything being equal, a firm's innovation capability, often measured by its patent holdings, is positively associated with its market performance (Hsu & Ziedonis, 2013). Hence, our findings suggest that founder CEOs' entrepreneurial innovation-seeking tendency may partially explain the theoretical relationship between founder CEOs and their firms' market performance.

Second, we contribute to the technological innovation literature by providing an alternative but complementary explanation for why entrepreneurial venture firms are better innovators than old and established incumbents (Christensen, 2013; Christensen & Bower, 1996; Tripsas, 1997). While previous studies have focused on the roles of entrepreneurial firms as innovators and provided a firm-level economic rationale for why incumbents maybe hesitant to pursue innovation, they have not devoted adequate attention to elucidating differences among important individuals who actually makes strategic choices in firms, i.e., allocating capital for innovative activities. Our study theoretically argues and empirically shows that entrepreneurs are more likely than professional managers to be innovators. Our findings suggest that entrepreneurial firms, which are often managed by founder CEOs, are more likely to pursue innovation than establishment firms, which are often managed by professional CEOs, owing to differences in not only the "economic situations of firms" but also the "personal characteristics of CEOs".

Third, our findings add to the general corporate governance literature that studies the link between CEO characteristics and firm-level behavior and performance (e.g., Hambrick, 1994; Hambrick & Mason, 1984; Westphal & Zajac, 1995) and the link between corporate governance and technological innovation (e.g., Aghion, Van Reenen, & Zingales, 2009; Lerner & Wulf, 2007). Extending the recent works on the relationship between CEO characteristics and technological innovation (e.g., Galasso & Simcoe, 2011; Hirshleifer, Low, & Teoh, 2012), we find that CEOs

who are the founder of their firms are better innovators than professional CEOs who have joined sometime after the establishment of the firm.

THEORY AND HYPOTHESES

Founder CEOs and Innovation

In the management and economics literature, entrepreneurs are often described as the center piece of innovation. In his seminal study, Schumpeter (1934) views the entrepreneur as the agent who discovers opportunities, initiates change, and actualizes unattempted endeavors. Ever since, innovation has been the focus of many entrepreneurial theories and has driven much of the literature to focus on entrepreneurs' role in bringing technological innovation to the world (e.g., Drucker, 2002; Shane & Venkataraman, 2000). However, we still lack systematic research on the relationship between the existence of a founder CEO in a firm and the firm's innovation performance. This lack of research is surprising since, as entrepreneurial ventures grow, founder CEOs are often replaced by professional CEOs, who substantially differ from founder CEOs in their skills, characteristics and choice of corporate strategies and policies (e.g., Boeker & Karichalil, 2002; Fahlenbrach, 2009; Wasserman, 2012). While entrepreneurs as individuals are considered change agents, whether entrepreneurs as managers of organizations may facilitate organizations' innovation performance is not obvious. In next subsections, we describe two theoretical arguments from the founder CEO literature that provide conflicting predictions regarding the effects of founder CEOs on firms' innovation performance.

Positive View on Founder CEOs (Founder CEO Literature)

Recent studies on founder CEOs provide several reasons why founder CEOs may be better innovators than professional CEOs. First, founder CEOs are entrepreneurial risk takers who are not afraid to invest in risky projects such as technological innovation (e.g., Busenitz & Barney,

1997; Kihlstrom & Laffont, 1979; Knight, 1921). By contrast, professional CEOs are more risk averse, and they hold more conservative expectations when engaging in high-risk behaviors (Gibson & Sanbonmatsu, 2004). Hence, founder CEO-managed firms are more likely to allocate capital to pursue innovation than professional CEO-managed firms. For example, based on his sample of large public firms, Fahlenbrach (2009) finds that founder CEO-managed firms invest more in R&D and have higher capital expenditure than professional CEO-managed firms. Furthermore, founder CEOs' risk-taking propensity may be reflected in employees' incentive schemes, which can increase firms' innovation performance (Lerner & Wulf, 2007). More important, founder CEOs with strong beliefs in entrepreneurial risk taking may attract employees with similar characteristics and beliefs about innovation through labor market selection (Van den Steen, 2005).

Second, founder CEOs have a more long-term growth orientation than professional CEOs (e.g., Miller et al., 2011; Villalonga & Amit, 2006). Previous studies have argued that founder CEOs have stronger commitment to their firms (Dobrev & Barnett, 2005; Jayaraman et al., 2000) and that they frequently consider their firms to be their "babies or legacies" (e.g., Nelson, 2003; Wasserman, 2006; Zahra, 2005). For example, in his study of new venture firms, Wasserman (2006) reasons that firm founders will be rewarded with higher levels of "psychic income" from their firms and will act as stewards by aligning their interests with the organizations' interests. Accordingly, he finds that founder CEOs will accept lower cash compensation than professional CEOs to work for the organization. Hence, the classic owner-manager conflict is lower in founder CEO-managed firms than professional CEO-managed firms (Villalonga & Amit, 2006). Furthermore, founder CEOs are less likely to suffer from job security risk and, in turn, are less sensitive to the short-term performance expectations of institutional investors (Souder, Simsek, &

Johnson, 2012). In sum, founder CEOs' intrinsic motivation and strong control of the organization allow them to allocate capital to long-term investments such as innovation and to suffer fewer agency problems, which will ultimately lower innovation performance. Therefore, we propose the following hypothesis:

H1: Founder CEO-managed firms experience greater innovation performance than professional CEO-managed firms.

Negative View on Founder CEOs (Corporate Lifecycle Literature)

By contrast, the corporate lifecycle literature suggests that founder CEOs may be worse innovators than professional CEOs or at most that they may not significantly differ from professional CEOs with respect to innovation performance. A main argument of the literature is that the founder CEOs may not possess the proper leadership skills to manage a larger and more established firm and may not be able to modify their management style and capabilities to match the growing firm's needs (Boeker & Karichalil, 2002; Boeker & Wiltbank, 2005). This literature suggests that as new startups substantially grow, CEOs' managerial styles and capabilities must evolve as firms' priorities shift from ensuring viability and survival to managing complex organizational systems (Boeker & Karichalil, 2002; Jain & Tabak, 2008; Tushman et al., 1985). The transition to a large corporation exposes CEOs to a new set of tasks owing to changes in the ownership and governance structure, employee size, increased market monitoring, and pressure to meet analyst expectations (Jain & Tabak, 2008). Thus, large companies require different characteristics from their CEOs (e.g., management skill, meeting investor needs, rational decision making) than new startups (e.g., entrepreneurial passion, visionary), and founder CEOs may therefore be unsuitable for managing established large companies (Boeker & Wiltbank, 2005; Wasserman, 2012). Hence, even though founder CEOs may have better entrepreneurial traits,

professional CEOs may be better skilled and experienced to lead organizations to generate greater innovation performance. For example, Wasserman (2003) shows that as the size of entrepreneurial firms managed by founder CEOs grows, founder CEOs are often replaced by professional CEOs by external shareholders (e.g., venture capital firms). He further argues and shows that this is true even when founder CEO-managed firms are performing well in the market since the shareholders consider the professional CEOs to be more suitable to lead the organizations that already passed the early-stages.

Furthermore, founder CEOs are often pressured to adjust their characteristics to become more suitable for leading large organizations since if founder CEOs fail to adapt to the new needs and conditions that large organizations require, they are often replaced by professional CEOs (Boeker & Fleming, 2010). Thus, founder CEOs in large organizations may therefore begin to think and behave more like professional CEOs, who make more rational, realistic, and logical decisions. Hence, founder CEOs may abandon their unique characteristics and behave similar to professional CEOs once the new startup becomes a large company. In sum, corporate lifecycle theory suggests that founder CEOs are worse, or at most similar, in leading their firms to innovate than professional CEOs.

H2: Founder CEO-managed firms experience worse or the same innovation performance as professional CEO-managed firms.

METHODS

Data and Sample

This paper combines multiple data sources to construct a novel dataset in order to study the effects of founder CEOs on technological innovation: (i) patent and citation data from the NBER patent database, (ii) CEO-level data from SEC filings and Execucomp, (iii) accounting and

financial data from Compustat and the Center for Research in Security Prices (CRSP), (iv) institutional ownership data from the Thomson Reuters Institutional Holdings (S34) 13F database, and (v) data from company websites and other web-based sources, such as Bloomberg, Businessweek, Financial Times, and Forbes.

Our primary sample consists of S&P 500 firms. We limit our sample period to 1993 to 2003 because of availability and truncation problems associated with the NBER patent database (Atanassov, 2015; Hirshleifer et al., 2012). The firms in our sample are large, publicly traded corporations over a broad cross-section of U.S. industries. We exclude financial (SIC 6000-6999) and regulated utilities (SIC 4911) companies because they are subject to different regulations from those in other industries. We then match these firms with those in the NBER patent data by assignee names and identifiers.[1] As we include all S&P 500 firms during our sample period with the exception of firms operating in financial and utilities industries, firms without patents are also present in our sample. We then track the founder and professional CEO status at the focal firm-year level by mainly using SEC filings such as proxy statements as the primary source for identifying founder CEOs and further rely on information about key executives provided by Execucomp, Bloomberg, Financial Times, and other web-based sources. To supplement the data with fundamental financial and accounting information, we also use various items from Compustat and CRSP. The final sample consists of 1,453 firms and 8,856 firm-year observations for the period between 1993 and 2003, and we identify 333 founder CEOs among the total of 2,354 CEOs.

Measures

Dependent variables: measuring innovation. As our main interest is firms' innovation output, we focus on patent-based measures as a proxy for publicly traded firms' innovation rather

[1] To combine patent data with our CEO information and other financial and accounting data, we use the Compustat firm identifier (GVKEY) by following the procedure suggested by Bessen (2009).

than R&D expenditure. We obtain information on the patenting activity of publicly traded firms from the 2006 NBER version of the U.S. Patent database created by Hall, Jaffe, and Trajtenberg (2001). This patent database provides various items with detailed information on patents, including assignee names and identifiers, patent number, number of citations received from subsequent patents, year of application and grant, and technology classes.

Our primary patent-based measure of innovation is constructed by counting the total number of citations that each patent receives in subsequent years up to 2006. Although patent-based measures are often criticized as an incomplete measure of innovation since patents vary widely in their technological and economic significance (Griliches, 1990), using the measure of citation-weighted patents can partially reduce this concern because the number of forward citations can represent the value of patents (e.g., Aghion, Akcigit, & Howitt, 2013; Hall et al., 2001). We regard a patent's application year as the time of innovation, because it more precisely captures the time when the patent is invented than the grant year. Moreover, since we are interested in the innovation performance that can be attributed to the behavior of different types of CEOs (i.e., founder CEOs and professional CEOs), the application year is more appropriate for measuring the innovation outcome for which a particular CEO is responsible (Galasso & Simcoe, 2011). Because a time lag exists between the application year and grant year (2.4 years in our sample), citation-weighted patent count are inherently subject to truncation problems (Hall et al., 2001). To address this problem, we first adjust the citation-weighted patent count by using the citation truncation weight item in the NBER patent database.[2] We also include year dummies to correct for the issue that patents filed in later years in our sample period may have less time to receive citations than

[2] Unless otherwise specified, citation-weighted patent count refer to the truncation-adjusted number of citations that a patent received from subsequent patents.

those filed in earlier years. Finally, as suggested by Hall et al. (2001), we limit our sample period to 2003 in order to allow 3 years for reliable citation counts.

For robustness, we also consider several alternative measures of innovation. First, we use two additional patent-based measures: the number of patents and the number of citations per patent. Specifically, the number of patents is constructed by counting the number of patents filed by a focal firm in a given year and eventually granted in later years, and the number of citations per patent is measured as the total number of citations received by each patent of a focal firm divided by the number of patents filed by the firm in a given year. We also include a measure of input into innovation by using R&D intensity, which is measured as R&D expenditure divided by the book value of total assets (Hirshleifer et al., 2012).

Furthermore, in our extension of analyses, we investigate the effects of the existence of a founder CEO on a firm's technological diversity and breakthrough innovations. Following prior studies (e.g., Vasudeva, Zaheer, & Hernandez, 2013), we derive technological diversity from the Herfindahl-Hirschman Index as follows: 1-$\sum_i p_i^2$, where p_i^2 indicates the proportion of patents in technology class *i* filed by a focal firm in a given year. We also include a measure of technological diversity based on a simple count of the technology classes of patents filed by a focal firm in a given year. To capture the effect of founder CEOs on the generation of impactful innovations that can serve as the basis for subsequent technological developments (Rosenkopf & Nerkar, 2001), we measure breakthrough innovation as the number of patents filed within the top 5 percent of patents in terms of the number of citations received in each patent class.

Identifying founder CEOs. The main independent variable in our model is *Founder CEO*. The identities of founder CEOs are primarily collected from securities filings from the SEC. In particular, annual reports, IPO prospectuses, and DEF 14A are credible sources for extracting not

only founder status but also other governance features, such as CEO ownership, CEO duality, and so forth (Daily, Certo, & Dalton, 2005). Second, we check the companies' official websites to determine whether they provide information about the companies' founder or co-founders. Third, we conduct Internet searches using CEOs' profile pages on Bloomberg Businessweek, Forbes, and Financial Times, among others. We identify 333 founder CEOs, composing approximately 14.6% of our sample, among 2,354 total CEOs in 1,453 firms. This variable is dichotomous, where zero indicates a professional CEO and one indicates a founder CEO.

Control variables. We incorporate several control variables at the firm and CEO level to capture the effects of other possible determinants of innovation performance. At the CEO level, we include standard demographics such as CEO gender and age. *CEO gender* is a dummy variable that takes the value of one if the CEO is female and zero otherwise (Maccrimmon & Wehrung, 1986), and *CEO age* is measured in years (Barker III & Mueller, 2002). We also include *CEO tenure* (Henderson, Miller, & Hambrick, 2006), which is a proxy for experience in a given firm, and *CEO duality* to account for managerial discretion (Rechner & Dalton, 1991). Finally, we also include controls that can represent CEOs' incentive to engage in innovative activities. Research shows that CEOs tend to have a long-term orientation when their interests and wealth are well-aligned with those of shareholders. Consistent with prior studies (e.g., Barker III & Mueller, 2002; Hirshleifer et al., 2012), we therefore include the proportion of CEO ownership, CEO delta and CEO vega (for option holdings). *CEO Ownership* is constructed as the proportion of outstanding shares owned by the corporate CEO in a given year. *CEO Delta*, a proxy for the sensitivity of CEO pay to performance, is measured as the change in a CEO's options and stock grants corresponding to a one percent change in the stock price, and *CEO Vega*, a proxy for the sensitivity of CEO wealth to stock return volatility, is calculated as the change in the value of options of the grants

corresponding to a one percent change in stock return volatility (e.g., Coles, Daniel, & Naveen, 2006).

Next, following the literature on innovation (e.g., Hall & Ziedonis, 2001; Hirshleifer et al., 2012), we include *Firm Size*, which is measured by the natural logarithm of total sales, and *Firm Age*, which is constructed as the natural logarithm of the number of years since the firm's inception. To capture the effects of capital availability and capital structure on firms' innovation activities, we control for the amount of *Cash* as a natural logarithm and the book leverage ratio (Opler, Pinkowitz, Stulz, & Williamson, 1999). We also control for accounting performance measured by return on assets (*ROA*) and market performance computed as *Stock Return* because firm performance can affect firms' propensity to invest in innovative activities (Hundley, Jacobson, & Park, 1996). A number of researchers have argued that descendant CEOs may have different strategic behavior than founder CEOs (e.g., Anderson & Reeb, 2003; Villalonga & Amit, 2006). We therefore include a binary variable that takes the value one when the firms are managed by descendants from their founders and zero otherwise. Finally, Aghion et al. (2013) suggest that innovation performance is positively affected by institutional holdings; thus, we account for the proportion of ownership held by all institutional investors (i.e., *Institutional Ownership*).

Empirical Design

Our primary empirical approach to examine the relationship between innovation and different types of CEOs is to estimate the following model using ordinary least squares (OLS) in a firm-year panel data set up:

$$Innovation_{i,t} = \alpha + \delta + T_t + \beta_1 Founder\ CEO_{i,t} + \boldsymbol{X_{i,t}}\beta_c + \varepsilon_{i,t},$$

where *i* indexes firms and *t* indexes years. *Founder CEO* is a dummy variable that equals one when firm *i* has a founder as its CEO at time *t*, $\boldsymbol{X_{i,t}}$ is a vector of control variables that can determine a

firm's innovation output (or input), and δ and T_t represent industry fixed effects and year fixed effects, respectively. The dependent variable, *Innovation*, can take one of our various measures of innovation, such as citation-weighted patent count, patent count, citations per patent, and R&D intensity. When R&D expenditure is included in the vector of control variables, $\boldsymbol{X}$, β_1 indicates whether firms with founder CEOs generate more innovations for the given R&D expenditure and thus represents R&D productivity or efficiency. By contrast, when R&D expenditure is removed from $\boldsymbol{X}$, β_1 reflects the effect of both efficiency and changes in R&D expenditure.

While our sample includes multiple observations per firm, it is important to note that CEO status is fairly constant over time. In our sample, 120 of the 1,453 firms experienced a change from the founder CEO to a professional CEO, and 12 of these 120 firms reversed back from a professional CEO to the founder CEO. While the fixed-effect estimation can account for the effects of unobserved firm-specific factors, considerable within-panel variation in the variable values is required to produce consistent and efficient estimates (Wooldridge, 1995). The fixed-effects panel OLS model therefore may only reflect partial variation of our sample because only 8.26 percent of firms experienced a succession event from the founder CEO to a professional CEO or vice versa. Hence, we also use a random-effects panel OLS estimation to understand the differences in innovation performance across firms with different types of CEOs.[3] Following previous studies (e.g., Hirshleifer et al., 2012; Vasudeva et al., 2013), we use log-transformed innovation as the dependent variable because our patent-based dependent variables are nonnegative and highly skewed, and robust standard errors clustered at the firm level are used to account for the nonindependence of the observations (Petersen, 2009).

[3] We also conduct a Hausman test to compare the estimates between the random-effects and fixed-effects models in the panel structure. Although the within-firm variations are not considerable, the test shows that the fixed-effects model is preferable, so we report the results from both the random-effects and fixed-effects models in order to test our main research questions (Tables 2 and 3). We find consistent results in most of our analyses for both the random-effects and fixed-effects models, which provides strong support for our predictions.

RESULTS

Table 1 provides descriptive summary statistics for all CEOs and separately for founder CEOs and professional CEOs. Sharp differences between firms with founder CEOs and firms with professional CEOs are apparent in the innovation performance variables and other control variables. On average, firms with founder CEOs have a higher citation-weighted patent count per year for both the raw and truncation-adjusted measures. Specifically, firms with founder CEOs have approximately 36 more raw citation counts and 82 more truncation-adjusted citation counts, and these differences are statistically significant at 5 percent level according to Wilcoxon-Mann-Whitney tests. Moreover, firms with founder CEOs tend to generate more breakthrough patents per year than firms with professional CEOs. As the average number of breakthrough patents for all firms is 1.47, a huge difference (0.47) is evident between firms with founder CEOs and firms with professional CEOs in their effectiveness in generating impactful innovations. With respect to the control variables, Table 1 shows that founder CEOs in general, manage younger and smaller firms and firms with lower leverage ratios, better performance (i.e., higher stock returns and higher ROA), and higher Tobin's Q. Consistent with prior studies suggesting that founders have a strong sense of attachment to their firms (e.g., Dobrev & Barnett, 2005; Jayaraman et al., 2000), founder CEOs are shown to accept lower compensation. Interestingly, founder CEOs tend to have a higher delta and a lower vega than professional CEOs, suggesting that founder CEOs are willing to accept compensation stocks that are more positively sensitive to stock price changes but not options that are sensitive to stock return volatility. Table 2 presents the correlation coefficients among the key variables in our study.

Insert Table 1 and Table 2 about here

Founder CEOs and Innovation

In Table 3, we report the first set of results of a random-effects panel OLS regression and a fixed-effects panel OLS regression, both of which show a positive association between the existence of a founder CEO and innovation performance. We use the natural logarithm of one plus citation-weighted patent count as a dependent variable to capture the quantity and quality of the innovations of the sample firms. For all models in Table 3, robust standard errors clustered at the firm level are used to correct for heteroscedasticity and to allow for serial correlation (Petersen, 2009). Models 1 and 4 are our baseline specifications that use control variables only.

In Models 2 and 5, we add our focal explanatory variable *Founder CEO*, and its coefficients demonstrate that the existence of a founder CEO in a firm has a positive effect on innovation performance. Specifically, the coefficient on *Founder CEO* in Model 2, a random-effects panel OLS, suggests that firms with founder CEOs obtain a 31 percent higher citation-weighted patent count than firms with professional CEOs, and this difference is driven by the heterogeneity between firms with founder CEOs and those with professional CEOs. Model 5 of a fixed-effects panel OLS also yields consistent results, which are driven by the change in CEO status within a firm.[4] In Models 3 and 6, we control for the amount of R&D expenditure to differentiate between the impact of R&D productivity (or efficiency) and increased innovative intensity resulting from a higher level of R&D expenditure. As the amount of R&D expenditure is not included in Models 2 and 5, the positive coefficients on *Founder CEO* can come from either increased R&D investment or enhanced R&D productivity, while the coefficients on *Founder CEO* in Models 3 and 6 capture the effect of the existence of a founder CEO in a firm at the given amount of R&D

[4] Although we include industry dummies in all models to control for industry-specific effects, they are automatically dropped in the fixed-effects panel OLS regressions, as our sample firms maintain their industry classification during our sample period.

investment. Although the coefficients on *Founder CEO* decline by 25 percent to 0.229 and by 6 percent to 0.287 in Models 3 and 6, respectively, they remain positive and significant, suggesting that firms with founder CEOs have greater efficiency in obtaining innovation performance than firms with professional CEOs.

Insert Table 3 about here

Founder CEOs and Level of Industrial Competition

The results of Table 3 provide strong support for Hypothesis 1, which proposes a positive association between the existence of a founder CEO and innovation performance. In Table 4, we further explore the mechanism by which founder CEO status affects innovation outcomes. As mentioned above, the main rationale behind the positive view on founder CEO is that entrepreneurial risk-taking behavior of founder CEOs can generate superior innovation outcomes compared to professional CEOs who are in general reluctant to accept high risks involved in innovative activities and vulnerable to short-term financial performance (Busenitz & Barney, 1997; Kihlstrom & Laffont, 1979; Knight, 1921). If this is the underlying mechanism of our main results, the effect of founder CEOs on innovation performance should be stronger in situations where the risks with respect to pursuing innovation are greater. Previous studies show that the level of industrial competition is often associated with high risk and low expected value of innovation outcomes because the value of innovations can be eroded easily due to the rivals' responses (Galasso & Simcoe, 2011; Roberts, 1999). Hence, we predict that the effect of founder CEOs on innovation performance will be more pronounced as the level of competition of an industry increases.

The models in Table 4 present the interaction effects between founder CEO and the level of industrial competition on innovation performance measured by citation-weighted patent count. These models are identical to the corresponding models in Table 3. We measure the level of competition in an industry as the number of firms identified by Compustat within the industry on three-digit SIC level (e.g., Li & Tang, 2010). Consistent with our prediction, the coefficients on the interaction between founder CEO and level of industrial competition are positive and statistically significant in both a random-effects and a fixed-effects OLS regressions. This indicates that the relationship between founder CEOs and innovation performance is stronger for firms facing a larger number of competitors, suggesting further evidence for the entrepreneurial risk-taking view of founder CEOs.

Insert Table 4 about here

Alternative Innovation Measures

While we use citation-weighted patent count as our main dependent variable to reflect the heterogeneous value of patents, in Table 5, we reexamine the models in Table 3 by using alternative innovation measures, including *Patent Count*, *Citations per Patent*, and *R&D Intensity*. These additional innovation measures enable us to investigate whether firms with founder CEOs obtain greater innovation through more patents, more impactful patents, or greater investment in innovative activities.

The dependent variable in Models 1 and 4 is calculated as the natural logarithm of one plus patent counts. The results for Model 1 indicate that firms with founder CEOs have 11 percent more patents filed in a given year (and eventually issued in later years) than firms with professional

CEOs, and the results of a fixed-effects panel OLS show little changes in the coefficient on *Founder CEO*. Models 2 and 5, which use *Citations per Patent* as the dependent variable, also show that the existence of a founder CEO in a firm is associated with an increased number of patents with a greater impact. Model 2, a random-effects panel OLS regression, shows that firms with founder CEOs, on average, obtain 2.8 more citations per patent, and this effect is increased to 3.9 more citations per patent in Model 5, which uses a fixed-effects panel OLS regression.[5] These results suggest that founder CEOs are driving superior innovation performance not by creating technologically meaningless patents but by creating impactful patents.

Finally, Models 3 and 6 examine the relationship between the existence of a founder CEO and spending on innovative activities computed as the amount of R&D expenditure divided by total assets (i.e., *R&D intensity*). In these models, we find that firms with founder CEOs have an approximately 3 percent higher level of R&D intensity than firms with professional CEOs in both the random-effects and fixed-effects panel OLS regressions. These results suggest that founder CEOs are also allocating a considerable amount of capital to generate better innovation performance, which contradicts the entrepreneurial myth that founder CEOs are creating innovation with only a limited amount of capital (Nicholson & Anderson, 2005).

In sum, the regression results in Table 5 suggest that the existence of a founder CEO in a firm has a strong positive association with innovation and that this positive effect is achieved through higher quantity and quality of outputs and greater inputs for innovative activities.

Insert Table 5 about here

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[5] The citations per patent variable takes a value of zero for firm-year observations with no patents. We also repeat our test while excluding self-citations for the measure of citations per patent, and our results remain similar.

Extensions

Patent Diversity and Breakthrough Patents. In this section, we investigate whether the existence of a founder CEO is associated with not only the quality and quantity of innovation but also the different dimensions of innovation performance. The literature on technology and innovation has suggested that firms possessing diverse technological capabilities can overcome the localness of knowledge and generate more impactful innovations by developing novel combinations of heterogeneous knowledge (Fleming, 2001; Rosenkopf & Nerkar, 2001). This research stream suggests that not only the amount or overall quality of innovations but diversity and radicalness of innovations can represent different dimensions of innovation performance. We therefore conduct several estimations using *Patent Diversity* and *Breakthrough Innovation* as outcome variables. Definitions of these variables are provided above in the Measure section.

In Table 6, we find that the existence of a founder CEO in a firm is positively associated with both of the patent diversity measures, as computed by the Herfindahl-Hirschman index and the number of patent classes, suggesting that firms with founder CEOs have a tendency to explore across different technological domains. Hence, this result implies that founder CEO-managed firms are more likely to be explorative than professional CEOs-managed firms in their knowledge search behavior (March, 1991).

Moreover, the random-effects panel OLS regression on *Breakthrough Innovations* (Model 3) shows that firms with founder CEOs also generate more breakthrough innovations, which have substantial impacts on subsequent patents in the same technology class. However, the coefficient on *Breakthrough Innovations* (Model 6) is no longer significant in the fixed-effects panel OLS, even though it has a similar value and direction, implying that time-invariant firm-specific effects are also involved in generating radical innovations.

Insert Table 6 about here

Effects on firm value. While founder CEOs may generate technologically meaningful patents as we have previously shown, these patents may not be economically more meaningful than patents generated by professional CEOs. For example, founder CEOs may be focused on generating "too innovative" technology that may not be successfully commercialized. In this case, while founder CEOs may generate more innovations, the innovations may not be actually translated into financial performance. Hence, we examine how the better innovation performance associated with the existence of a founder CEO in a firm affects the firm's financial value, as measured by Tobin's Q.

The results in Table 7 provide evidence that the effect of a firm's innovation performance, as measured by its citation-weighted patent count, on its market performance is more pronounced when the CEO of the firm is a founder. Consistent with the prior literature (e.g., Fahlenbrach, 2009; Hall, Jaffe, & Trajtenberg, 2005; Villalonga & Amit, 2006), the results of Model 1, which uses a random-effects panel OLS regression without an interaction term, show that the coefficients on both *Founder CEO* and *Innovation Performance* are statistically significant and positive.[6] Once the interaction term between these two variables is included in Model 2, these two variables are no longer significant; however, the interaction term between them has a strong positive relationship with market performance, as measured by Tobin's Q. Our interaction results are consistent even for the fixed-effects panel OLS regression model (Model 4). Figure 1 depicts the

[6] As suggested by Hall et al. (2005), innovation performance measured by patent citations is positively associated with firm value. Prior studies have also shown that firms with founder CEOs, on average, have a higher market valuation and stock market performance owing to their different characteristics from professional CEOs (Fahlenbrach, 2009; Villalonga & Amit, 2006).

effect of innovation performance (i.e., the natural logarithm of one plus citation-weighted patent count) on firm value measured as Tobin's Q by different types of CEOs while other variables are held constant at their mean values. When a firm's CEO is a founder, a one-standard-deviation increase in the value of innovation performance above the mean increases the firm value by 8.4 percent. However, when a firm is managed by a professional CEO, a one-standard-deviation increase in the value of innovation performance above the mean increases the firm value by only 2.2 percent (see Figure 1).

Overall, these results provide one of the first explanations for why founder CEO-managed firms enjoy higher market performance than professional CEO-managed firms. Our results suggest that the higher market performance of founder CEO-managed firms is generated by having both a greater number of innovations and higher quality innovations than professional CEO-managed firms.

Insert Table 7 and Figure 1 about here

Robustness Checks

Endogeneity. The empirical results reported above show that a strong and consistent association exists between the existence of a founder CEO in a firm and the firm's innovation performance, as proxied by various measures. The specific concern, however, is that our results may be subject to a selection bias problem if founder CEOs have a willingness to maintain a CEO position when strong potential innovation opportunities exist or if innovative firms tend to have founder CEOs rather than professional CEOs. In an ideal setting, we would randomly assign founder CEOs to firms and investigate how their innovation performance differs from the

innovation performance of firms managed by professional CEOs. Instead, we attempt to address this issue by using a number of different approaches. First, we employ a propensity score matching method (Rosenbaum & Rubin, 1983). Second, we estimate the effect of different type of CEOs on the innovation performance by using subsample analyses consisting of longer-tenured CEOs. Finally, we analyze the changes in innovation performance within a firm by comparing the innovation trends before and after the change in CEO status for firms that experienced a switch from a founder CEO to a professional CEO.

The propensity score matching method can reduce the potential for endogeneity concerns stemming from a selection problem by controlling for observable differences between firms with founder CEOs and those with professional CEOs. We first identify 120 firm-year observations in which firms experienced a switch from a founder CEO to a professional CEO, and we then match these observations with those in which no such an event occurred. The propensity score is calculated by using a probit model, which estimates the probability of a switch event with all control variables used in Model 2 of Table 3.

Table 8 shows the estimation results of *Founder CEO* on innovation performance measured by citation-weighted patent count for the matched sample. We estimate Model 1 via OLS using only matched firm-year observations, while we include all panel observations of the matched sample in Models 2 and 3. Consistent with the results in Table 3, all models in Table 8 show statistically significant and positive coefficients on *Founder CEO*, and the value of the coefficients on *Founder CEO* in Models 2 and 3 are somewhat larger than the corresponding coefficients in Models 2 and 5 of Table 3, which alleviates the concern that a selection problem may bias our main findings.

Insert Table 8 about here

Next, to further address the endogeneity issue, we restrict our sample to a subset of firms with relatively long-tenured CEOs. The idea is that founders may stay in their firms as a CEO during the period in which they expect more opportunities for successful innovations. However, such opportunities will not last for a long period because the availability and likelihood that the opportunities will yield successful innovations depend on firms' internal resources and capabilities as well as the external environments at a given time period. Thus, selection effects should be strongest when a CEO is first appointed (Hirshleifer et al., 2012). That is, founder CEOs will be replaced by professional CEOs when founder CEOs expect that the innovation opportunities are very small around the replacement period. Therefore, limiting our sample observations to firms with CEOs who have stayed in a firm for a longer period can reduce the concern regarding an endogenous selection problem. We reexamine the effect of the existence of a founder CEO in a firm after eliminating observations from the sample for which *CEO Tenure* is relatively short and apply a number of different tenure cutoffs from 4 to 8 years. Table 9 shows the effect of the existence of a founder CEO in a firm for sample observations restricted to firms with long-tenured CEOs. The models in this table are identical to Model 2 of Table 2. Model 1 restricts the sample to firms with CEOs whose tenure is longer than 4 years, whereas Models 2 and 3 limit the sample to firms with CEOs whose tenure is longer than 6 and 8 years, respectively. In all models, our focal explanatory variable, *Founder CEO*, still has a statistically significant and positive association with innovation performance measured by citation-weighted patent count, although the values of coefficients decrease slightly from the corresponding coefficient in Model 2 of Table 3. These

findings are consistent with our previous analyses and support the view that the existence of a founder CEO in a firm improves firms' innovation performance.

Insert Table 9 about here

Finally, we perform a subsample analysis to see whether there is a discernible difference in the trend of within firm innovation performance around a switch event from a founder CEO to a professional CEO. Following previous studies that examine the changes in various firm features around a critical firm level event (e.g., Sheen, 2014; Siegel & Simons, 2010), we restrict our sample to a subset of firms that experienced a switch event from a founder CEO to a professional CEO and examine whether a firm's innovation performance remains the same after a switch event (i.e., the period during which the firm is managed by a professional CEO) as before the event (i.e., the period during which a firm is managed by a founder CEO). If we find a different trend in innovation performance within a firm between the pre-CEO change period and post-CEO change period, then our baseline results can be confirmed with a reduced concern of an endogenous selection problem. Figure 2 shows the year-by-year progression in innovation performance graphically by plotting the coefficients plus the constant term from a fixed-effects panel OLS regression of innovation performance measured by the natural logarithm of one plus citation-weighted patent count on a set of year-relative to CEO change dummies. This figure indicates that the trend in innovation performance during the pre-CEO change period does not appear to continue during the post-CEO change period, while there is a significant drop in innovation performance in the year of the CEO change event, suggesting that a causal link exists between the existence of a founder CEO in a firm and innovation performance.

Insert Figure 2 about here

Other Robustness Checks. We first consider whether our main results are robust to an alternative specification. Instead of using the log-transformed dependent variables (i.e., *ln(Citation_Adjusted+1)* and *ln(Patent+1)*), we use raw citation-weighted patent count and the number of patents as our dependent variables for innovation performance. As these variables have nonnegative integers, we estimate using both negative binomial models with random effects and fixed effects and find that results are qualitatively similar to our main results.

Next, as our sample include all S&P 500 firms between 1993 and 2003, many observations in our data include zero citation-weighted patent count and zero number of patents in firm-year level, which may bias our estimations. It is possible that our results are driven by these firms which are mostly in the industry where innovation and patenting activities are not important which may diminish the meaning of our findings. We therefore restrict our sample to innovative industries and conduct subsample analyses to see whether the effect of founder CEOs on innovative performance differs depending on the industry innovativeness. We define innovative industries as industries where the average citation-weighted patent count is greater than median citation-weighted patent count across all industries in our sample (Hirshleifer et al., 2012), and find the results of subsample analyses remain consistent to our main results.[7]

During technology boom period between 1998 and 2000, the Internet provided many opportunities with which entrepreneurs and existing firms could achieve innovations over a wide

[7] We also conduct the same subsample analyses using firms in high-technology industries identified by American Electronics Association (AEA)'s industry definitions, and find the similar results.

range of business activities (Litan & Rivlin, 2001). As innovation performance may be affected in a way that is driven by our sample period, we therefore examine the effect of the existence of a founder CEO on innovation performance while excluding this technology boom period from our sample. The results of our untabulated analysis show that the existence of a founder CEO in a firm still has a positive association with all of the different proxies for innovation performance for the subsample that excludes the technology boom years 1998-2000.[8]

CONCLUSION

Motivated by the mixed theoretical predictions on the relationship between the type of CEO and innovation performance, we investigate whether the existence of a founder CEO in a firm fosters innovation in large, publicly traded firms. We find strong empirical support that over the 1993–2003 period, a founder CEO is associated with greater investment in innovative activities and greater innovation as measured by the citation-weighted patent count, number of patents, and citations per patent even after we control for the amount of R&D expenditure. In other words, the R&D investments of founder CEO-managed firms are more effective and efficient in generating innovation.[9] We find that the positive effect of founder CEOs on innovation is stronger in more competitive industries. We also find that firms with founder CEOs have a tendency to explore diverse technological domains and to generate substantially impactful innovations that can provide new potential opportunities for subsequent technological developments. We interpret these findings as evidence that founder CEOs are more likely to positively affect their firm's innovation strategy.

[8] All results in this subsection can be provided upon request.

[9] We note that our findings do not imply that founder CEOs make optimal R&D investments. Because we use indirect measures of innovation value and because we have no information on the opportunity costs of funds, we cannot rule out overinvestment or poor project selection.

Our findings are particularly convincing since the results are consistent across various robustness checks that control for potential selection issues and other endogeneity concerns. Founder CEO's existence in a firm is endogenous, and it might be affected by unobserved firm characteristics. More specifically, if founder CEOs can identify innovation opportunity with higher expected success probability, they may engage in cherry picking behavior. We mitigate the potential selection bias and other endogeneity concerns in four ways. First, we include firm-fixed effects to control for potential unobserved time-invariant endogeneity concerns during our sample period. Second, we mitigate the selection problem by using a propensity score matching method. Third, to further address the endogeneity issue, we perform subsample analyses that include only relatively long-tenured CEOs. We find that a founder CEO remains a strong and significant predictor of innovation performance even when we remove CEOs with short tenures at their firms, which suggests that the endogenous hiring of founder CEOs by innovative firms is not the main driver of our findings. Fourth, using a subset of firms that experienced a switch event from a founder CEO to a professional CEO, we examine whether the trend in the firms' innovation performance remains the same after a switch event (i.e., the period during which the firm is managed by a professional CEO) as before the event (i.e., the period during which the firm is managed by a founder CEO).

Our findings are especially interesting in light of the recent studies suggesting that founder CEO-managed firms exhibit superior market performance and accounting performance than professional CEO-managed firms (e.g., Adams et al., 2009; Fahlenbrach, 2009; Villalonga & Amit, 2006). While these studies have provided compelling empirical evidence that founder CEO-managed firms financially outperform professional CEO-managed firms, they do not provide systematic evidence on why founder CEO-managed firms outperform professional CEO-managed

firms. Our study complements this literature and suggests that since firms' innovation capabilities are positively associated with their market performance (Hall, 1999; Hall et al., 2005; Hsu & Ziedonis, 2013), founder CEOs' entrepreneurial innovation-seeking tendency may partially explain the theoretical relationship between founder CEOs and market performance.

In conclusion, this study compares the effect of founder CEOs and professional CEOs on firms' innovation performance. We have argued and shown that founder CEOs have different characteristics than professional CEOs and substantially affect their firm's innovation effectiveness and efficiency. In addition, we also find that founder CEOs differ in their innovation direction and impact from professional CEOs. We hope that our results will encourage scholars to explore the link between CEO characteristics and strategic decisions and to consider such choices in the context of technological innovation including both innovation inputs (e.g., R&D expenditure) and innovation outputs (e.g., patents, new product developments).

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TABLE 1

Summary Statistics[a]

	All CEOs				Founder CEO		Professional CEO		Differences
Variables	M	SD	Min	Max	M	SD	M	SD	T-test
Citation (Raw) Count	82.21	528.93	0	16539	111.76	578.51	76.23	518.16	35.537**
Citation (Adj.) Count	189.45	1173.36	0	34660.36	257.97	1328.13	175.59	1139.09	82.381**
Patents Count	11.3	58.96	0	1706	12.22	58.49	11.12	59.06	1.104
Patents Diversity	0.2	0.32	0	0.98	0.19	0.32	0.2	0.33	-0.011
Patents Class Diversity	2.97	8.38	0	129	2.76	7.5	3.02	8.56	-0.259
Breakthrough Innovation	1.47	8.49	0	244	1.87	9.79	1.4	8.2	0.472*
Tobin's Q	1.66	1.35	0.36	6.34	2.24	1.68	1.55	1.25	0.087***
R&D/Assets	0.25	0.29	0	4.41	0.33	0.32	0.24	0.28	0.695***
Female CEO	0.02	0.12	0	1	0.01	0.12	0.02	0.13	-0.002
CEO Age	54.79	7.95	28	89	55.67	10.08	54.61	7.43	1.057***
CEO Ownership	0.03	0.08	0	0.94	0.09	0.11	0.02	0.06	0.066***
(ln) CEO Tenure	1.73	0.91	0	3.97	2.54	0.77	1.57	0.84	0.966***
(ln) CEO Compensation	6.54	0.98	0	9.8	6.36	1.03	6.57	0.96	-0.213***
(ln) CEO Option	4.8	3.35	0	12.82	4.56	3.59	4.84	3.3	-0.284***
(ln) CEO Vega	3	1.76	0	9.34	2.86	1.87	3.03	1.73	-0.179***
(ln) CEO Delta	4.42	2.21	0	12.19	5.7	2.18	4.16	2.13	1.539***
CEO Duality	0.2	0.4	0	1	0.24	0.43	0.2	0.4	0.047***
Institutional Ownership[b]	0.4	0.31	0	1.5	0.41	0.3	0.4	0.32	0.008
(ln) Firm Age	3.44	0.93	0	5.43	2.84	0.59	3.56	0.93	-0.721***
(ln) Firm Size	6.56	1.6	0	11.52	5.98	1.5	6.68	1.6	-0.694***
Book Leverage	0.35	0.3	0	1.65	0.25	0.27	0.37	0.3	-0.123***
Stock Return	0.02	0.16	-0.63	1.89	0.03	0.18	0.02	0.16	0.008*
ROA	0.01	0.16	-0.88	0.26	0.01	0.17	0.01	0.16	0.008*
Sales Growth	0.09	0.19	-0.65	8.31	0.1	0.15	0.09	0.2	0.008
(ln) Cash	3.51	1.61	-0.17	9.27	3.51	1.55	3.51	1.62	0.009
Descendants CEO Firm	0.07	0.25	0	1	0.08	0.27	0.06	0.24	0.014**
N of Firms	1,453				323		1,130		
N	8,856				1,490		7,366		

[a] T-tests (Wilcoxon-Mann-Whitney tests) are conducted to test for differences between the means for firms with founder CEOs and firms with professional CEOs.

[b] Because shares that are shorted are owned by more than one party, institutional ownership can exceed 100 percent in some cases (Asquith, Pathak, & Ritter, 2005).

* $p < .10$

** $p < .05$

*** $p < .01$

TABLE 2

Correlation Matrix[a]

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1. (ln) Citation_Adj.	1.00																							
2. (ln) Citation_Raw	**0.93**	1.00																						
3. Citation/Patent	**0.63**	**0.41**	1.00																					
4. Tobin's Q	**0.14**	**0.11**	**0.16**	1.00																				
5. R&D/Assets	**0.58**	**0.58**	**0.34**	**0.33**	1.00																			
6. Founder CEO	**0.03**	-0.00	**0.08**	**0.19**	**0.11**	1.00																		
7. Female CEO	**-0.05**	**-0.05**	**-0.04**	0.01	**-0.04**	-0.01	1.00																	
8. CEO Age	**0.03**	**0.04**	**-0.05**	**-0.13**	**-0.05**	**0.05**	**-0.05**	1.00																
9. CEO Ownership	**-0.09**	**-0.10**	**-0.03**	**0.05**	**-0.10**	**0.33**	0.01	**0.14**	1.00															
10. (ln) CEO Tenure	-0.01	**-0.03**	0.00	**0.08**	-0.02	**0.40**	**-0.04**	**0.34**	**0.31**	1.00														
11. (ln) CEO Comp.	**0.13**	**0.17**	0.00	**-0.05**	-0.01	**-0.08**	0.01	**0.07**	**-0.10**	**0.07**	1.00													
12. (ln) CEO Option	**0.18**	**0.19**	**0.08**	**0.12**	**0.18**	**-0.03**	0.01	**-0.11**	**-0.17**	**-0.11**	**0.21**	1.00												
13. (ln) CEO Vega	**0.18**	**0.22**	**0.07**	**0.08**	**0.13**	**-0.04**	0.01	**-0.05**	**-0.15**	**0.03**	**0.36**	**0.46**	1.00											
14. (ln) CEO Delta	**0.12**	**0.13**	**0.08**	**0.26**	**0.09**	**0.26**	-0.01	**0.06**	**0.31**	**0.31**	**0.19**	**0.13**	**0.56**	1.00										
15. CEO Duality	**-0.06**	0.01	**-0.11**	**-0.05**	**0.02**	**0.04**	**0.03**	**0.07**	**0.02**	**0.10**	**0.09**	**0.06**	**0.17**	**0.09**	1.00									
16. Inst. Ownership	**0.08**	**0.08**	**0.05**	**0.08**	**0.09**	0.01	0.01	**0.03**	**-0.09**	**0.03**	**0.12**	**0.11**	**0.23**	**0.14**	**0.11**	1.00								
17. (ln) Firm Age	**0.03**	**0.06**	**-0.10**	**-0.24**	**-0.14**	**-0.29**	0.00	**0.24**	**-0.06**	**0.04**	**0.19**	**-0.03**	**0.03**	**-0.05**	**0.04**	**0.05**	1.00							
18. (ln) Firm Size	**0.15**	**0.21**	**-0.03**	**-0.28**	**-0.18**	**-0.16**	**-0.05**	**0.15**	**-0.07**	**-0.05**	**0.45**	**0.16**	**0.32**	**0.18**	**0.08**	**0.07**	**0.33**	1.00						
19. Book Leverage	**-0.09**	**-0.06**	**-0.13**	**-0.25**	**-0.22**	-0.15	-0.03	**0.08**	**-0.07**	**-0.09**	**0.11**	-0.02	**0.02**	**-0.11**	**0.03**	**-0.08**	**0.17**	**0.29**	1.00					
20. Stock Return	**0.05**	**0.04**	**0.04**	**0.12**	**0.09**	0.02	0.01	**-0.04**	-0.01	**-0.02**	0.00	0.02	0.00	0.02	0.01	-0.01	**-0.07**	**-0.09**	**-0.04**	1.00				
21. ROA	0.01	-0.00	0.01	**0.09**	**-0.19**	0.02	-0.01	**0.09**	**0.06**	**0.11**	**0.20**	**0.02**	**0.13**	**0.22**	**-0.08**	**0.17**	**0.15**	**0.30**	**-0.17**	**-0.06**	1.00			
22. Sales Growth	**-0.05**	**-0.05**	**-0.03**	**0.02**	**-0.08**	0.02	-0.02	-0.03	0.02	0.01	-0.01	0.00	0.00	**0.02**	0.00	-0.01	**-0.03**	0.01	0.00	-0.01	**0.06**	1.00		
23. (ln) Cash	**0.26**	**0.32**	**0.09**	**0.10**	**0.23**	**0.00**	-0.01	**0.00**	**-0.05**	**-0.04**	**0.31**	**0.23**	**0.33**	**0.21**	**0.16**	**0.05**	0.01	**0.44**	**-0.06**	**0.03**	**0.09**	-0.02	1.00	
24. Descend. CEO	**-0.09**	**-0.09**	**-0.05**	**-0.04**	**-0.15**	**0.02**	0.01	**0.05**	**0.14**	**0.11**	**0.04**	**-0.11**	**-0.08**	**0.05**	-0.02	**-0.02**	**0.13**	**0.05**	-0.01	**-0.03**	**0.07**	0.01	**-0.02**	1.00

[a] N=8,856. Bolded pairwise correlations are significant at the 0.05 level

TABLE 3

Innovation Performance of Founder CEO versus Professional CEO[a]

Dependent Variable	*ln (Citation_Adjusted+1)*					
	Panel OLS Random			Panel OLS Fixed		
Models	1	2	3	4	5	6
Founder CEO		**0.305*** (0.105)**	**0.229** (0.098)**		**0.305** (0.132)**	**0.287** (0.130)**
(ln) R&D Expenditure			0.371*** (0.041)			0.113** (0.053)
Female CEO	0.121 (0.109)	0.138 (0.110)	0.130 (0.106)	0.156 (0.129)	0.176 (0.131)	0.173 (0.130)
CEO Age	0.004 (0.004)	0.003 (0.004)	0.003 (0.004)	0.005 (0.004)	0.004 (0.004)	0.004 (0.004)
CEO Ownership	-1.022*** (0.350)	-1.226*** (0.347)	-1.079*** (0.337)	-0.906** (0.385)	-1.071*** (0.380)	-1.064*** (0.382)
(ln) CEO Tenure	-0.008 (0.026)	-0.032 (0.027)	-0.030 (0.027)	0.007 (0.028)	-0.013 (0.029)	-0.014 (0.029)
(ln) CEO Compensation	0.025 (0.030)	0.028 (0.029)	0.028 (0.028)	0.008 (0.032)	0.010 (0.032)	0.011 (0.031)
(ln) CEO Option	0.007 (0.006)	0.006 (0.006)	0.006 (0.006)	0.005 (0.006)	0.005 (0.006)	0.005 (0.006)
(ln) CEO Vega	0.018 (0.017)	0.022 (0.017)	0.013 (0.017)	0.006 (0.018)	0.009 (0.018)	0.006 (0.018)
(ln) CEO Delta	0.023* (0.013)	0.019 (0.013)	0.018 (0.013)	0.023* (0.014)	0.020 (0.014)	0.021 (0.014)
CEO Duality	0.031 (0.059)	0.024 (0.060)	0.029 (0.060)	-0.003 (0.064)	-0.009 (0.065)	-0.007 (0.065)
Institutional Ownership	0.061 (0.101)	0.064 (0.101)	0.037 (0.100)	0.061 (0.118)	0.067 (0.118)	0.056 (0.119)
(ln) Firm Age	-0.027 (0.061)	0.001 (0.062)	0.018 (0.054)	-0.276 (0.173)	-0.244 (0.173)	-0.245 (0.174)
(ln) Firm Size	0.184*** (0.039)	0.188*** (0.039)	0.125*** (0.034)	0.078* (0.042)	0.082** (0.041)	0.062 (0.041)
Book Leverage	-0.230** (0.106)	-0.222** (0.105)	-0.205** (0.100)	-0.167 (0.115)	-0.161 (0.114)	-0.162 (0.113)
Stock Return	0.007 (0.088)	0.008 (0.088)	0.011 (0.086)	-0.031 (0.090)	-0.030 (0.090)	-0.029 (0.089)
ROA	-0.095 (0.134)	-0.090 (0.133)	0.099 (0.133)	0.136 (0.137)	0.141 (0.135)	0.191 (0.134)
(ln) Cash	0.038** (0.019)	0.037** (0.019)	0.013 (0.018)	-0.007 (0.020)	-0.007 (0.020)	-0.012 (0.019)
Sales Growth	-0.098* (0.058)	-0.098* (0.058)	-0.084 (0.060)	-0.079 (0.057)	-0.080 (0.057)	-0.077 (0.058)
Descendant CEO Firm	-0.362** (0.154)	-0.361** (0.151)	-0.213 (0.140)	-0.200 (0.416)	-0.168 (0.370)	-0.202 (0.374)
Constant	1.429 (0.998)	1.395 (0.992)	0.918 (0.784)	1.753*** (0.650)	1.647** (0.643)	1.635** (0.646)
Industry Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
N of Firms	1,453	1,453	1,453	1,453	1,453	1,453
N	8,856	8,856	8,856	8,856	8,856	8,856
R^2	0.376	0.377	0.480	0.406	0.407	0.504

[a] Robust standard errors clustered at the firm level are in parentheses.

* p < .10

** p < .05

*** p < .01

TABLE 4

Effects of Industrial Competition[a]

Dependent Variable	*ln(Citation_Adj.+1)*			
	Panel OLS Random		Panel OLS Fixed	
Models	1	2	3	4
Founder CEO		**0.001****		**0.001*****
X Industrial Competition		**(0.000)**		**(0.000)**
Founder CEO	0.304***	0.097	0.311**	-0.008
	(0.105)	(0.107)	(0.133)	(0.131)
Industrial Competition	0.001***	0.001**	0.001*	0.001
	(0.000)	(0.000)	(0.000)	(0.000)
Control Variables	Included	Included	Included	Included
Constant	1.312	1.303	1.525**	1.470**
	(0.996)	(0.997)	(0.653)	(0.654)
Industry Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*
Year Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*
Number of Firms	1,453	1,453	1,453	1,453
N	8,856	8,856	8,856	8,856
R^2	0.381	0.379	0.414	0.414

[a] Robust standard errors clustered at the firm level are in parentheses.

* p < .10
** p < .05
*** p < .01

TABLE 5

Alternative Innovation Performance Measures[a]

Dependent Variables	***ln (Patent+1)***	***Citations per Patent***	***R&D Intensity***	***ln (Patent+1)***	***Citations per Patent***	***R&D Intensity***
	Panel OLS Random			Panel OLS Fixed		
Models	1	2	3	4	5	6
Founder CEO	**0.114****	**2.778****	**0.032****	**0.113***	**3.870****	**0.031****
	(0.054)	**(1.087)**	**(0.013)**	**(0.063)**	**(1.887)**	**(0.015)**
Control Variables	Included	Included	Included	Included	Included	Included
Constant	0.583	16.276***	0.422***	0.212	35.147***	0.216***
	(0.624)	(4.059)	(0.107)	(0.299)	(6.727)	(0.040)
Industry Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
N of Firms	1,453	1,453	1,453	1,453	1,453	1,453
N	8,856	8,856	8,856	8,856	8,856	8,856
R^2	0.375	0.166	0.608	0.417	0.407	0.640

[a] Robust standard errors clustered at the firm level are in parentheses.

* p < .10
** p < .05
*** p < .01

TABLE 6

Patent Diversity, Patent Class Diversity, and Breakthrough Innovation[a]

	Panel OLS Random			Panel OLS Fixed		
Dependent Variables	Patent Diversity	Patent Class Diversity	Breakthrough Innovation	Patent Diversity	Patent Class Diversity	Breakthrough Innovation
Models	**1**	**2**	**3**	**4**	**5**	6
Founder CEO	**0.026** **(0.012)**	**0.073** **(0.034)**	**0.075** **(0.038)**	**0.031*** **(0.016)**	**0.070*** **(0.040)**	0.074 (0.051)
Control Variables	Included	Included	Included	Included	Included	Included
Constant	-0.056 (0.128)	0.004 (0.359)	0.325 (0.316)	0.041 (0.087)	0.129 (0.212)	0.377 (0.243)
Industry Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
N of Firms	1,453	1,453	1,453	1,453	1,453	1,453
N	8,856	8,856	8,856	8,856	8,856	8,856
R^2	0.361	0.397	0.264	0.3775	0.4335	0.2919

[a] Robust standard errors clustered at the firm level are in parentheses.
* p < .10
** p < .05

TABLE 7

Interaction Effects of Founder CEO and Innovation Performance on Market Performance[a]

Dependent Variable	***Tobin's Q***			
	Panel OLS Random		Panel OLS Fixed	
Models	1	**2**	3	**4**
Founder CEO X Innovation Performance		**0.045** **(0.023)**		**0.057** **(0.027)**
Founder CEO	0.177** (0.072)	0.089 (0.079)	0.102 (0.102)	-0.016 (0.109)
Innovation Performance	0.024** (0.011)	0.014 (0.012)	-0.001 (0.014)	-0.014 (0.015)
Control Variables	Included	Included	Included	Included
Constant	3.611*** (0.426)	3.617*** (0.429)	4.101*** (0.603)	4.111*** (0.601)
Industry Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*
Year Fixed Effects	*Yes*	*Yes*	*Yes*	*Yes*
N of Firms	1,331	1,331	1,331	1,331
N	7,376	7,376	7,376	7,376
R^2	0.274	0.275	0.297	0.298

[a] In this table, all control variables are lagged by one year. Robust standard errors clustered at the firm level are in parentheses.
** p < .05
*** p < .01

TABLE 8

Propensity Score Matching[a]

Dependent Variable	***ln (Citation_Adj+1)***		
	1 vs 1 Matching	**1 vs 1 Matching Panel**	
	OLS	**Panel OLS Random**	**Panel OLS Fixed**
Models	**1**	**2**	**3**
Founder CEO	**1.767** **(0.798)**	**0.472**** **(0.233)**	**0.519**** **(0.254)**
Control Variables	Included	Included	Included
Constant	-1.851 (1.679)	-0.282 (0.916)	0.834 (1.808)
Industry Fixed Effects	*No*	*Yes*	*Yes*
Year Fixed Effects	*Yes*	*Yes*	*Yes*
N of Firms	240	240	240
N	240	1,592	1,592
R^2	0.299	0.466	0.426

[a] In this table, we report propensity score matching results. We identify 120 firms that experience founder CEO succession to professional CEOs. We obtain propensity scores by calculating the probability of the succession event with all control variables that we use in this paper.

* p < .10
** p < .05
*** p < .01

TABLE 9

Excluding Firms with Short-Tenured CEOs[a]

Panel OLS Random			
Dependent Variable	***ln (Citation_Adj+1)***		
Models	**1**	**2**	**3**
CEO Tenure	**CEO Tenure>4**	**CEO Tenure>6**	**CEO Tenure>8**
Founder CEO	**0.278**** **(0.136)**	**0.353**** **(0.140)**	**0.256*** **(0.151)**
Control Variables	Included	Included	Included
Constant	0.972 (1.033)	0.226 (1.073)	-0.187 (1.204)
Industry Fixed Effects	*Yes*	*Yes*	*Yes*
Year Fixed Effects	*Yes*	*Yes*	*Yes*
N of Firms	1267	1030	799
N	5334	4047	3103
R^2	0.423	0.446	0.466

[a] Robust standard errors clustered at the firm level are in parentheses.

* p < .10
** p < .05

FIGURE 1

Interaction Effect between Innovation Performance and Founder CEO on Firm Value

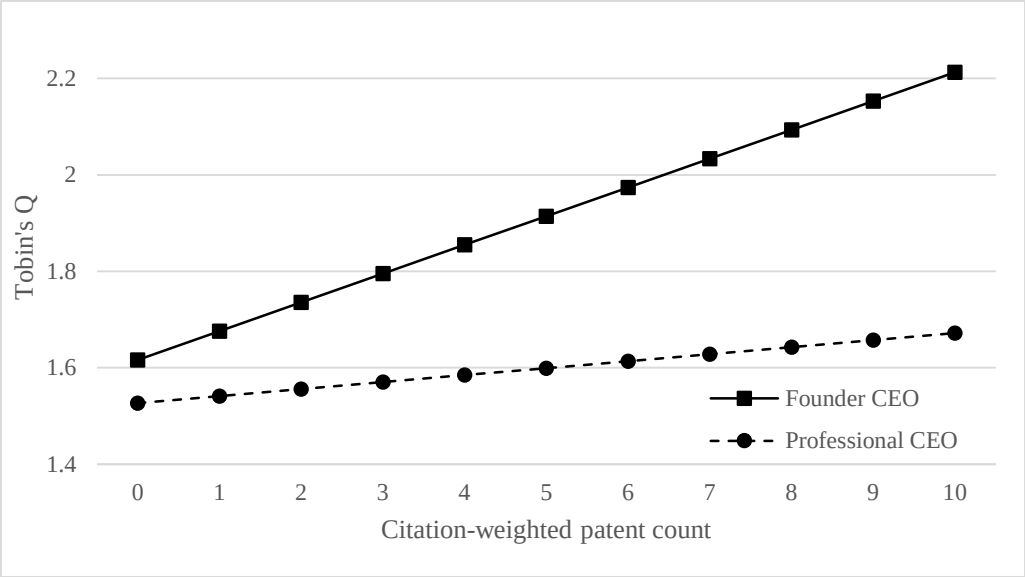

FIGURE 2

Switching from Founder CEO to Professional CEO