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Innovation, CEOs, and IPOs

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ABSTRACT

In Part 1, I study if CEOs with innovative ability impose a cost upon their firms. I find that while there is a positive effect of a CEO's innovative ability on firm innovation, the benefit is only when CEO's innovative ability is useful for the firm. Further, firms with innovator CEOs spend more on R&D projects but with lower efficiency and hold more cash but with lower cash value compared to firms with non-innovator CEOs. These results suggest that innovator CEOs create an overinvestment problem. In Part 2, I study the effects of talent cycling on IPO long-run performance and the consequences to the IPO market. Talent cycling in initial public offerings refers to the job seeking behavior in high-tech firms where talented patent inventors leave once an IPO is successful and then pursue another job at a private firm. In my sample, I find that 36% of IPO firms have patent inventors who went to a non public firm within one year after an IPO and those inventors are the best talent in the firm. The negative side of talent cycling is that firms affected by talent cycling underperform firms unaffected by talent cycling for up to four years post IPO, while the positive side of talent cycling is the increase of the probability of an IPO in the economy. In robustness tests, I show that talent cycling is different from human capital loss and the results are robust to different time periods, such as bubble periods and hot market periods. In Part 3, I study the impact of an innovator CEO on the IPO's underpricing, long-run performance, and post-IPO innovation. I find that since CEOs' innovative ability can reduce the information asymmetry in the IPO market, firms led by innovator CEOs experience lower first-day return (less underpricing) compared to firms led by non-innovator CEOs. Firms with innovator CEOs have greater IPO long-run performance compared to firms with non-innovator CEOs. I also find that firms with innovator CEOs have more firm innovation up to four years after the IPO compared to firms with non-innovator CEOs.

DEDICATION

This dissertation is dedicated to my fiancé, who encouraged and supported me through this process, and to my parents who have always motivated me to always give my best effort.

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APPENDIX OF CONTENTS

LISTS OF APPENDICES

PART 1: CEOS WITH INNOVATIVE ABILITY

I. INTRODUCTION

In the last 50 years, many successful businesses have been led by creative genius entrepreneurs. Islam and Zein (2018) find that innovator CEOs increase firm innovation for high-tech firms. Yet, Michael Jeffries, the former CEO of Abercrombie & Fitch (A&F), has five patents and was considered one of the greatest CEOs in retail history.[1]. Jeffries became the CEO of A&F in 1992. During his tenure, A&F's stock price increased from initial offer price of $16 per share in October 1996 to an all-time high of $84.23per share by October 2007. However, by November 2008 A&F stock price had dropped to a low of $14.64. In 2014 Jeffries finally stepped down as CEO and was blamed for the 11 straight quarters of negative company comparable-store sales.[2] Upon announcement of Jeffries stepping down, A&F stock price jumped 8%, the biggest one-day price gain in the past nine months. The Jeffries-A&F example raises several questions. Do innovator CEOs matter for less innovative industries? Is there cost of having an innovator CEO? Why might there be costs to having an innovator CEO? This paper examines these questions.

Innovation has long been recognized as important because innovation plays a critical role in promoting economic growth (Solow, 1957) and increases the probability of a firm's survival (Cefis and Marsili, 2006). Since the CEO is the most important person in an organization (Ireland and Hitt, 1999) and research and development (R&D) spending is one of the most

[1] https://www.salon.com/2006/01/24/jeffries/
[2] https://www.bloomberg.com/news/articles/2014-12-09/abercrombie-fitch-ceo-mike-jeffries-to-step-down-immediately

fundamental investment decisions made by firms (Barker and Mueller, 2002), it follows that motivating the CEO to pursue firm innovation is an important area of research. Literature shows that extrinsic motivations of a CEO pursuing firm innovation, such as standard pay-for-performance contracts, do not encourage innovation in a firm (Manso, 2011), and performance-contingent financial incentives can even inhibit innovation (Ariely, Gneezy and Loewenstein, 2009; Hellmann and Thiele, 2011; Ederer and Manso, 2013). However, intrinsic motivations of CEOs pursuing firm innovation, such as their age, education and tenure, can foster innovation in a firm (Barker and Mueller, 2002; Wu, Levitas and Priem, 2005). A large literature in economics of science shows that people are attracted to pursue innovation by the explicit economic incentives, but by their intrinsic motivation, such the personal taste for science and the intellectual challenge associated with scientific work (e.g., Sauermann and Cohen, 2010). Sunder, Sunder and Zhang (2017) examine the intrinsic motivations by looking at the role of the CEO's personality traits of sensation-seeking on firm's innovation. They find that CEOs with pilot licenses are associated with more firm innovation.

To examine the effects of a CEO's innovative ability on a firm's innovation, I use patents and citations to measure a CEO's innovative ability. Using a sample of 2,134 U.S. public firms and 3,952 CEOs from 1992 to 2008 from all industries,[3] I find that firms with innovator CEOs who have at least one patent experience more innovation compared to firms with non-innovator CEOs. CEOs with greater innovative ability spur more innovation to firms. However, CEOs with innovative ability in the innovative industry lower firm innovation compared to less innovative industry, suggesting the potential overinvestment problem. Innovator CEOs spur firm innovation only when CEOs' innovation is useful for the firm. That is, a CEO's innovative ability impacts

[3] There are 340 CEOs (9.9%) that are also patent inventors in the sample.

firm's innovation only when the CEO's patent and the firm belong to the same industry classification. I also find that the effect of innovator CEOs on firm stock performance and firm innovation is a long-run effect. Specifically, firms with innovator CEOs have greater abnormal buy-and-hold stock return starting the third year of hiring innovator CEOs compared to firms with non-innovator CEOs. CEOs' innovation ability can impact firm innovation in the long-run but the effects of CEOs' innovative ability on firm innovation decrease over time.

However, such characteristics that benefit corporate innovation may not be without a cost. Prior research finds that a CEO's personal characteristics can lead to distortions in corporate investment policies (Malmendier and Tate, 2005a; Malmendier and Tate, 2005b), overinvestment problems (Campbell, Gallmeyer, Johnson, Rutherford and Stanley, 2011) or value-destroying investments (Goel and Thakor, 2008). If CEOs with innovative ability have passion and interests in investing in innovation, they might pursue their own interests and overinvest in R&D projects. Agency theory also suggests that CEOs may overinvest to build excessive empires (Jensen and Meckling, 1976; Jensen 1986) and entrench themselves (Shleifer and Vishny, 1989) if they pursue their own interests. Bebchuk and Stole (1993) build a theoretical model and assume that the market has incomplete information about the investment returns, and if managers signal the market, the investors can observe the level of investments. They find that when the investors can only observe the level of the investments, overinvestment will occur in the firms. Therefore, CEOs with innovative ability may be more likely to signal investment opportunities to the market, and firms led by innovative CEOs are more likely to have overinvestment problems.

I study the potential overinvestment problems that are brought by innovator CEOs. Findings indicate that firms with innovator CEOs spend more on R&D projects, but this R&D

funding is used less efficiently than firms with non-innovator CEOs. The results are consistent with agency theory that innovator CEOs have overinvestment problems. To examine how these agency conflicts are manifested in other corporate policies, I further examine the level of cash holding and the value of cash holdings for firms with innovator CEOs.[4] I find that firms led by innovator CEOs hold more cash than firms led by non-innovator CEOs but the cash value is lower. Overall, the results suggest that while innovator CEOs spur greater firm innovation, they also tend to overinvest in innovation. These results are robust to the alternative CEOs' innovative ability measure, firm innovation measure, and alternative CEO ability measures, such as CEO's past industry working experience and CEO's general ability index.

One significant concern with looking at CEOs with innovative ability is that innovative firms are more likely to hire CEOs with greater innovative ability, which begs the question of whether the results are driven not by CEOs' innovative ability itself, but other omitted characteristics that are associated with innovative firms themselves. To address the potential endogeneity, I employ three methods. First, I use two-stage least square (2SLS) regression with the CEO coauthors' ability as an instrumental variable. The CEO coauthors' ability is a valid instrumental variable since the CEO coauthors' ability is related to a CEO's innovative ability and affects firm's innovation only through the CEO's innovative ability. Second, I apply a difference-in-difference methodology using CEO exogenous turnover as a shock.[5] Third, I use the propensity score matching method. Regardless of the methodology used, results indicate that a CEO's innovative ability has a positive impact on firm's innovation.

[4] Cash value captures the value that shareholders place on an extra dollar of cash held by firms.
[5] The results for the difference-in-difference methodology is in the appendix.

This paper is related to two other papers: Makri and Scandura (2010) and Islam and Zein (2018). Makri and Scandura examine the effects of creative CEO leadership on innovation. They find that creative leadership has a positive impact on the quality and quantity of firm innovation. My paper differs from Makri and Scandura and Islam and Zein in two ways. First, Makri and Scandura use CEO interviews and code information pertaining to leadership style, emphasizing developing social and human capital, as a proxy for CEO creative characteristics. This paper uses the number of patents and citations to directly quantify CEOs' innovative ability. While Islam and Zein (2018) define innovation using CEO patents, they emphasize the first-hand innovation experience of inventor CEOs and define "an inventor CEO" as one that has been awarded at least one patent. In addition to using Islam and Zein's definition, I focus on measuring the innovation ability of CEOs by counting patents and citations in each year, up to a given year or in the sample period. This allows me the test the incremental benefits or costs of CEOs' innovative ability within the firm. Second, Makri and Scandura (2010) and Islam and Zein (2018) only examine CEOs in the high-tech industry. My sample includes firms from all industries. This allows me to examine if the effect of CEOs with innovation ability on firm's innovation is greater when the firms are in the industries that need innovation the most. Most importantly, this paper is addressing the potential costs, not just the benefits, of having an innovator CEOs.

This paper contributes to the literature in mainly three ways. First, this paper is complementary to a growing body of literature that explores the effects of CEOs on corporate innovation. Barker and Mueller (2002) study the impact of CEO characteristics on firm's R&D spending; Custodio, Ferreira and Matos (2017) investigate whether general managerial skills spur innovation; Galasso and Simcoe (2011) study CEO overconfidence and firm innovation; and Sunder, Sunder and Zhang (2017) examine the effect of CEO sensation seeking on firm innovation. I add to this literature by showing that CEOs' innovative ability is a significant driver of corporate innovation, albeit at the cost of overinvestment, reduced innovative efficiency, and excessive cash holdings.

Second, this paper also complements the literature that studies the impact of CEO characteristics on the distortions in corporate investment decisions (Malmendier and Tate, 2005a; Malmendier and Tate, 2005b; Campbell, Gallmeyer, Johnson, Rutherford and Stanley, 2011; Goel and Thakor, 2008). Weisbach (1995) examines the impact of CEO turnover on firm's investment decisions; Bebchuk and Stole (1993) study CEO investment decisions in the presence of imperfect information; and Malmendier and Tate (2005a) investigate the effect of CEO overconfidence on corporate investment. I show that CEOs' innovative ability and intrinsic incentives for innovation can also distort corporate investments. Third, this paper uses a new proxy of CEO's ability that can affect firm's innovation: CEO patents and citations. This new proxy is a more direct and effective measure of a CEO's innovative ability compared to the current proxies (e.g. CEO's education and general ability index (Custodio, Ferreira and Matos, 2017)).

II. HYPOTHESES DEVELOPMENT

Ever since Schumpeter (1911), one of the most influential economists of the 20th century, proposed that technological innovation is the cause of economic growth, the effect of innovation on firms' performance has been studied extensively (Pakes, 1985; Austin, 1993; Nicholas, 2008; Kogan, Papanikolaou, Seru and Stoffman, 2017). For example, Hall, Jaffe and Trajtenberg (2005) find that innovation, measured by patents and citations, significantly positively affects the firm's market value and one extra citation of a patent increases the firm market value by three percent.

In addition to the importance of innovation on the firm's performance, researchers document that innovation is affected by stock liquidity (Fang, Tian and Tice, 2014), shareholder protection laws (Brown, Martinsson and Petersen, 2013), antitakeover laws (Atanassov, 2013), banking competition (Cornaggia, Mao, Tian and Wolfe, 2015), corporate venture capital (Chemmanur, Loutskina and Tian, 2014), analyst coverage (He and Tian, 2013) and institutional ownership (Aghion, Van Reenen and Zingales, 2013). However, innovative work is person centered (Mumford, Scott, Gaddis and Strange, 2002). Innovative people, the most direct influence of firm's innovation, are seldom studied. Moreover, innovative work often needs collaboration among people (Abra, 1994; Cagliano, Chiesa and Manzini, 2000) and interaction between employees and leaders (Pelz, 1963; Tierney, Farmer and Graen, 1999).[6] Furthermore,

[6] Specifically, Tierney, Farmer and Graen (1999), focusing on 191 R&D employees of a large chemical company, find that the interactions between employee intrinsic motivation and leader intrinsic motive is related to employee creative performance.

Mumford, Marks, Connelly, Zaccaro and Reiter-Palmon (2000) point out that organizational leaders must appraise the works of innovative people. It would be difficult to evaluate the innovative ideas if the leader lacks expertise or creative skills (Mumford, Scott, Gaddis and Strange, 2002). Therefore, the CEO, the leader of the organization and in charged with motivating employees and driving changes within the organization, with innovative ability will improve a firm's innovation. Islam and Zein (2018) also find that innovator CEOs impact firm innovation for high-tech industry.

Hypothesis 1: A CEO's innovative ability has a positive effect on the firm's innovation for all the industries.

Mumford (2000) and Redmond, Mumford and Teach (1993) find that CEOs play a key role on helping innovative people in the firm meet organizational needs and goals, and further CEO expertise and innovative skills are more important when the firm's tasks become more complex (Mumford, Scott, Gaddis and Strange, 2002). Thus, the effect of CEOs with innovative ability on firm's innovation and performance should be larger on firms that need CEOs with innovative ability the most. Moreover, Brown, Fazzari and Peterson (2009) document that the young high-tech industry accounts for about 75% of the entire U.S. R&D boom, indicating the importance of innovation to high-tech industry.

Hypothesis 2: The effect of a CEO's innovative ability is larger on the innovative industry compared to the less innovative industry.

According to agency theories, when CEOs pursue their own interests, the CEOs will overinvest to build excessive empires (Jensen and Meckling, 1976; Jensen 1986). Also, CEOs are interested in investments that require their own specific skills, and making such investments can entrench them since it is costly for shareholders to replace them (Shleifer and Vishny, 1989). Xuan (2009) also finds that firms with specialist CEOs have a lower investment efficiency.[7] Therefore, firms with innovator CEOs might have a lower innovation efficiency.

Hypothesis 3: Firms led by innovator CEOs have a lower innovation efficiency.

The value of holding cash is to allow a firm to undertake valuable projects when they are available (Almeida, Campello, and Weisbach, 2004; Han and Qiu, 2007). Since firms with innovator CEOs are more likely to invest in R&D projects (Makri and Scandura, 2010), I expect firms led by innovator CEOs to hold more cash compared to firms led by non-innovator CEOs. Moreover, since holding more cash can allow CEOs to invest in projects that offer non-pecuniary benefits but jeopardize shareholder's value (Jensen and Meckling, 1976), according to agency theory, I expect firms with innovator CEOs to hold more cash but have a lower cash value compared to firms with non-innovator CEOs.

Hypothesis 4: Firms led by innovator CEOs hold more cash compared to firms led by non-innovator CEOs but have a lower cash value.

[7] Xuan (2009) study the job histories of CEOs and define a specialist CEO as a CEO advanced through the ranks from certain divisions in the firm.

III. SAMPLE CONSTRUCTION, VARIABLE MEASUREMENTS AND SUMMARY STATISTICS

SAMPLE CONSTRUCTION

The data is collected from several difference sources. CEO characteristics are from ExecuComp, which provides names, title, and compensation related information for S&P 1500 firms starting from 1992. Firm financial information is from Compustat, stock returns are from Center for Research in Security Prices (CRSP), and firm patent data is provided by Kogan, Papanikolaou, Seru and Stoffman (2017) from 1975 to 2010. According to Hall, Jaffe, Trajtenberg (2001), there is a 2-year lag on average between a patent's application date and grant date with patents being granted eventually. Since the actual timing of innovation is closer to the date of application, I use the application year as the relevant year to match this patent dataset with other datasets and end my sample period in 2008. As a result, my sample period is from 1992 to 2008.

Following many existing studies on innovation (e.g. Sunder, Sunder and Zhang, 2017), I exclude financial and utilities firms. I then include all the other industries where the average number of patents per firm is at least one. This restriction allows the sample to include firms with zero patents but at the same time excludes industries where innovation is not relevant. The resulting sample includes 2,134 firms and 3,952 CEOs from 1992 to 2008.

VARIABLE MEASUREMENTS

This subsection defines the independent variable, dependent variable and control variables.

MEASURING CEOS' INNOVATIVE ABILITY

To identify innovator CEOs, I first obtain a list of CEO names from ExecuComp database, which includes the top paid executives of S&P 1500 firms. Then, I merge CEOs' names with patent inventors' names by their first, middle and last name. The data for patent inventors comes from Harvard Business School (HBS) patenting database constructed by Li, Lai, D'Amour, Doolin, Sun, Torvik, Amy and Fleming (2014). HBS patenting database provides unique identifiers (variable: Invnum_N) for each patent's inventors from 1975 through 2010. Although CEO's name is matched to inventor's name, there is still a possibility that the CEO and the inventor are not the same person but just have the same name. In some cases, the CEO's name can be matched to several unique inventors because of the same name. Therefore, I hand collect biographical information to ensure I am accurately matching CEOs with inventors.

The HBS patenting database contains inventor's patent assignee names, and ExecuComp contains CEO's company name. If the inventor's patent assignee name and CEO's company name are the same, it is a one-to-one match, and I identify the patent inventor and the CEO as the same person. If the inventor's patent assignee name and CEO's company name are not the same, it is not a one-to-one match. In this case, I search for the CEO's biographical information on the internet.[8] If the CEO's past working company name is the same as the inventor's patent assignee name, then I identify the patent inventor and the CEO as the same person. Sometimes, the CEO's biography directly indicates that the CEO invented patents. In that case, I identify the CEO as the patent inventor even though the CEO never worked for the patent assignee.[9] Using this process, my sample has 340 CEOs who are patent inventors (innovator CEOs) and 3,612 CEOs who are not patent inventors.[10]

Since HBS patenting database provides each patent's citations,[11] I construct eight metrics to measure CEOs' innovative ability in order to measure the quantity and quality of their innovative ability. The first measure (variable: Innovator CEO) is a dummy variable equal to one if the CEO had any patents during 1975 to 2010.[12] Based on this measure, there are 340 innovator CEOs in the sample. The second measure (variable: CEO patent) counts the number of patents the CEO applied for in a given year.[13] The third measure (variable: CEO citation) counts the number of citations subsequently received by the patents applied for in a given year. Patent citations measure the quality of the patent capturing the technology and economic importance.

[8] I first look up the websites providing the most credible and accurate information about the CEO. The first type of websites is the company website, Bloomberg CEO Biography and Wikipedia. If the CEO's biography cannot be found on those websites, I will go to other website to find CEO biography. For example, Notable Names Data Base, LinkedIn, news information and Forbes website.

[9] This is because the inventor sold the patent to the assignee. Therefore, the patent belongs to the assignee but the inventor never worked for the assignee.

[10] I successfully identified 366 CEOs who are patent inventors, but after merging the CEOs database with other databases, only 340 innovator CEOs were left in the sample.

[11] HBS patenting database provides design patents as well as utility patents. According to U.S. Patent and Trademark Office (USPTO), "a utility patent protects the way an article is used and works, while a design patent protects the way an article looks". Specifically, the utility patent is a trademark protection that makes sure a person has full control over his or her invention. A design patent is used when a person creates a new design for an existing product. However, the NBER patent database and Kogan, Papanikolaou, Seru and Stoffman (2017) dataset only provide utility patents. The NBER patent database provides inventor information only from 1975 to 1999 and does not provide inventor unique identifier. Kogan et al. dataset does not contain the patent inventors' information.

[12] Even though my sample period is 1992 to 2008, the HBS patent database has information from 1975 to 2010. So if a CEO had a patent in 1985, I recognize this CEO as an innovator CEO.

[13] Patents applied for are generally granted with a two years lag. Thus, date of application is closer to the actual timing of innovation than the patent grant date (Hall, Jaffe and Trajtenberg, 2001).

The fourth measure (variable: CEO avg. citation) is the ratio of CEO citation to CEO patent in a given year. The second, third and fourth measurements capture CEO's innovative ability in each year. However, CEOs' innovation ability is also reflected by their past innovation record. When a new CEO is announced, the stock market valuing the CEO's innovative ability will be based on the CEO's cumulative innovation record, not just one year. Therefore, the fifth, sixth and seventh measurements of CEOs' innovation ability are cumulative measures. The fifth measure (variable: CEO cumulative patent) is the cumulative number of patents up to that year starting the year the first patent was applied for and the sixth measure (variable: CEO cumulative citation) is the cumulative number of citations received by the patents up to that year starting the year the first patent was applied for. The seventh measure (variable: CEO cumulative avg. citation) is the ratio of CEO cumulative citation to CEO cumulative patent. The last measure (variable: CEO total avg. citation) is the ratio of CEO total citation over CEO total patent in the sample period. I only present the results using the first and seventh measures, innovator CEO and CEO cumulative average citation.

MEASURING FIRM'S INNOVATION

I measure firm innovation using data from Kogan et al. (2017),[14] which reports all utility patents issued by U.S. Patent and Trademark Office (USPTO). This patent database provides each patent assignee's CRSP unique identifier (variable: PERMNO), the citations received by each patent, the estimated value of the patent in nominal dollars, the patent's class, the application date and the grant date.

[14] HBS patent database does not provide patent assignee's CRSP unique identifier (PERMNO).

I use five metrics measuring the firm's patenting activity as proxies for the firm's innovation productivity. The first measure (variable: Firm patent) is a simple count of the number of patents the firm applied for in a given year. In order to capture the variation of the patent's technology importance, the second measure (variable: Firm citation) counts the number of citations subsequently received by the patents that the firm applied for in a given year. I log the first two measures due to the skewness distribution. The third measure (variable: Firm avg. citation) is the ratio of firm citation over firm patent in a given year.

In order to further capture the variation of the patent's technology importance and adjust for citation truncation lags (Hall, Jaffe, Trajtenberg, 2005), I follow Kogan et al. (2017) to construct the fourth measure (variable: Citation-weighted firm innovation) using this metric,

$$\omega_{i,t} = \sum_{j \in P_{i,t}} \left(1 + \frac{C_j}{\overline{C_J}}\right), \ (1)$$

where $\overline{C_J}$ is the average number of citations received by the patents that were granted in the same year as patent j, C_j is the number of citation received by patent j, $P_{i,t}$ is the set of patents issued to firm i in year t, and $\omega_{i,t}$ is the sum of the weight of citations on each patent plus one for firm i in time t. Since $\omega_{i,t}$ is increasing in firm size (Kogan et al., 2017), $\omega_{i,t}$ is scaled by book assets,

$$W_{i,t}^{cw} = \frac{\omega_{i,t}}{B_{i,t}}, (2)$$

where $B_{i,t}$ is book assets of firm i in year t, and $W_{i,t}^{cw}$ is the citation-weighted innovation for firm i firm in time t.

Citations value the scientific contribution of the patents but not necessarily the value added by the patents. For example, a firm invents a patent that generates only a few citations, but that patent restricts the development of its competitors. The patent will have a large value impact. Thus, the last measure of firm innovation (variable: Market-value firm innovation) uses the patents' private economic value. Following Kogan at el. (2017), market-value firm innovation is constructed using the stock market response to news about the patents.[15] The total dollar value of innovation produced by firm i in year t is equal to the sum of all the values of patents j granted to that firm,

$$\theta_{i,t} = \sum_{j \in P_{i,t}} x_j \ , (3)$$

where x_j is the dollar value of patent j, and $\theta_{i,t}$ is the total dollar value of patents applied by firm i in year t. Similar to citation-weighted firm innovation, market-value firm innovation is standardized by book assets,

$$W_{i,t}^{mv} = \frac{\theta_{i,t}}{B_{i,t}} \ , (4)$$

where $W_{i,t}^{mv}$ is the market-value firm innovation.

CONTROL VARIABLES

In order to investigate the effect of an innovator CEO on firm's innovation, other factors that would affect a firm's innovation must be controlled. In the regression, I control for time-varying firm characteristics and CEO specific variables. Following the innovation literature, controls include firm size, defined as the nature logarithm of total assets, capital intensity,

[15] Kogan at el. (2017) provides the dollar value of each patent based on the stock market response to news about the patents.

defined as the nature logarithm of the ratio of net property, plant, and equipment divided by the number of employees, stock return, defined as the firm's buy-and-hold return over the fiscal year, and Tobin's Q, defined as the natural log of the ratio of market value of assets to book value of assets.

CEO specific variables include CEO tenure, defined as the number of months a CEO is in the firm, CEO age in years, the delta of the CEO's stock and option portfolio (a proxy for CEO pay-performance sensitivity) and the vega of the CEO's stock and option portfolio (a proxy for CEO risk taking incentives). The calculation method for delta and vega is proposed by Core and Guay (2002), and the data for delta and vega is provided by Coles, Daniel and Naveen (2006). The delta is defined as the dollar change in CEO stock and option portfolio for 1% change in stock price, and the vega is defined as the dollar change in CEO option holdings for 1% change in stock return volatility. I also control for year fixed effects, industry fixed effects and firm fixed effects. All control variables are lagged by one year.

SUMMARY STATISTICS

Table 1 presents the distribution of innovator CEOs by year and by industry. Panel A displays the percentage of innovator CEOs in the sample by year. On average, 9.9% of CEOs in the sample are patent inventors. The percentage of innovator CEOs ranges from 6.8% (1993) to 11.7% (1999). The percentage of innovator CEOs is higher during the technology bubble period, suggesting firms in the technology industry are more likely to have innovator CEOs. Panel B tabulates the percentage of innovator CEOs by Fama and French 12 industry groups excluding financial firms and utilities.[16] Business equipment has the highest percentage of innovator CEOs (17.0%), followed by consumer durables (15.0%) and health (14.3%).[17] Panel C shows the percentage of innovator CEOs in the sample by high-tech industry following the categorization in Loughran and Ritter (2004).[18] High-tech industries have 18.0% of innovator CEOs compared to 7.6% in non-high-tech industries.

Table 2 provides summary statistics of dependent variables and independent variables in the regressions. I divide the sample into two subsamples, non-innovator CEOs and innovator CEOs, and report the means, medians, and standard deviations for the variables used in the regressions.[19] T-tests (Wilcoxon-Mann-Whitney tests) are also conducted to test for differences between the means (medians) for firms with innovator CEOs and non-innovator CEOs. As expected, firms with innovator CEOs have more patents, citations, average citations per patent, citation-weighted firm innovation and market-value firm innovation than firms with non-innovator CEOs. The differences on mean and median are both statistically significant. Also, firms with innovator CEOs spend a higher proportion of R&D over total assets than firms with non-innovator CEOs.

Examining innovator CEO's innovative ability, I find that on average, innovator CEOs have 0.82 patents and 12.21 citations per year, and cumulative 9.86 patents and 260.14 citations

[16] The Fama and French indsutries are defined in Fama's website. http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html#Research

[17] The Business Equipment industry might not have the highest percentage of innovator CEO since I exclude some sub-industries where the average patent per firm is less than one.

[18] In Loughran and Ritter (2004) appendix D, high-tech stocks are defined as those in SIC codes 3571, 3572, 3575, 3577, 3578 (computer hardware), 3661, 3663, 3669 (communications equipment), 3671,3672, 3674, 3675, 3677, 3678, 3679 (electronics), 3812 (navigation equipment), 3823,3825,3826,3827,3829 (measuring and controlling devices), 3841, 3845 (medical instruments), 4812, 4813 (telephone equipment), 4899 (communications services), and 7371, 7372, 7373, 7374, 7375, 7378, and 7379 (software).

[19] The summary statistics of dependent variables and independent variables in the regressions for the full sample are in the apendix Table 1A.

up to a given year. Comparing the firm characteristics for firms led by innovator CEOs and those led by non-innovator CEOs, I find that firms with innovator CEOs are smaller in size and have less capital intensity and higher Tobin's Q on average. There is no significant difference in stock return for firms with innovator CEOs and firms with non-innovator CEOs. Further, innovator CEOs have longer tenure, and higher delta and vega values in their compensation packages than non-innovator CEOs. There is no significant difference in inventor CEO age and non-inventor CEO age.

IV. INNOVATOR CEO AND FIRM INNOVATION

In this section, I first examine the effect of CEOs with innovative ability on firm innovation controlling for endogeneity problem. Then, I study the industry innovativeness. Next, I examine how innovator CEOs spur firm innovation and the innovation efficiency in the firm with innovator CEOs.

PATENTING ACTIVITY

OLS RESULTS

Table 3 presents the effects of innovator CEOs on firm's innovation. The regression model follows:

$$\begin{aligned} Firm\ innovation_{i,t+1} &= \alpha_1 + \beta_1 CEO\ innovative\ ability_{i,t} + \beta_2 Log(assets)_{i,t} \\ &+ \beta_3 Log\ (capital\ intensity)_{i,t} + \beta_4 Stock\ return_{i,t} + \beta_5 Tobin's\ Q_{i,t} \\ &+ \beta_6 Log\ (1 + tenure)_{i,t} + \beta_7 CEO\ age_{i,t} + \beta_8 Log\ (1 + delta)_{i,t} \\ &+ \beta_9 Log\ (1 + vega)_{i,t} + \gamma_k + \delta_t + \tau_t + \varepsilon_i, \qquad (5) \end{aligned}$$

where, $Firm\ innovation_{i,t+1}$, is measured by the five methods previously described, γ_k, δ_t and τ_t are year fixed effects, industry fixed effects and firm fixed effects respectively. All other variables are as previously defined.

In Panel A, $CEO\ innovative\ ability_{i,t}$ is measured by *Innovator CEO,* which is a dummy variable equal to one if the CEOs had any patent between 1975 and 2010. I find that *Innovator CEO* is positively statistically significant related to firm's innovation measured in all five proxies when the year fixed effects and industry fixed effects are controlled. When firm fixed effects are controlled, *Innovator CEO* is positively statistically significant related to firm's innovation only when firm innovation is measured by firm average citation per patent and citation-weighted firm innovation. In Panel B, I find that if CEOs have higher innovative ability based on their previous average citations per patent, firms have a greater number of patents, citations, average citations per patent and citation-weighted firm innovation when the year fixed effects and industry fixed effects or firm fixed effects are controlled. The results suggest a positive relationship between CEOs' innovative ability and firm's innovation, supporting hypothesis one that firms led by innovator CEOs tend to have more innovation for all the industries.[20]

Examining the control variables, I find that higher firm innovation is associated with bigger firms consistent with Sunder, Sunder and Zhang (2017). Furthermore, as in Hirshleifer, Low and Teoh (2012), I find that higher firm innovation is associated with firms with poor stock performance and high Tobin's Q. Vega values is generally positive consistent with Coles, Naveen and Naveen (2006). CEO age is negatively associated with firm innovation, suggesting that younger CEOs are better in innovation.

[20] The results of using the other six measures of a CEO's innovative ability are presented in appendix Table 2A. The results are consistent with hypothesis one.

ENDOGENEITY

If highly innovative firms are more likely to hire an innovator CEO, then β_1 in equation (5) is biased due to endogeneity. I control for endogeneity in two ways: 1) an instrument variable approach, and 2) propensity score matching.[21]

2SLS RESULTS

2SLS (two-stage least square) requires a selection of instrumental variables (IV). Successful IV candidates must satisfy two criteria. First, the IV must correlate with *CEO innovative ability,* and second, the IV does not correlate with the error term in equation (5). In another words, the IV affects the firm's innovation only through *CEO innovative ability.* I construct an IV using the coauthor's information. *CEO coauthors' ability* is defined as CEO coauthors' average number of citations over average number of patents.[22] I do not include any patents that the CEO coauthors have with the innovator CEO in the calculation of the IV.[23] I choose *CEO coauthors' ability* as an IV since people with higher innovative ability are more likely to work with other people with higher innovative ability. To implement the IV approach, I estimate the following first-stage regression:

[21] I also employ the difference-in-difference method by using an exogenous shock of CEO turnover to deal with the endogeneity issue. The results are presented in the appendix Table 5A. The results are consistent with hypothesis one.
[22] CEO coauthors' average citation is defined as the average citation the coauthor has shared with other authors. CEO coauthors' average patent is defined as the average patent the coauthor shared with other authors.
[23] I also manually check 50 CEOs' coauthors and find that CEO coauthors and CEOs do not work in the same company. Therefore, CEO coauthors and CEOs working in the same company is very rare.

$$CEO\ innovative\ ability_{i,t}$$

$$= \alpha_1 + \beta_1 CEO\ coauthors'\ ability_i + \beta_2 Log(assets)_{i,t} + \beta_3 Log\ (capital\ intensity)_{i,t} + \beta_4 Stock\ return_{i,t} + \beta_5 Tobin's\ Q_{i,t} + \beta_6 Log\ (1 + tenure)_{i,t} + \beta_7 CEO\ age_{i,t} + \beta_8 Log\ (1 + delta)_{i,t} + \beta_9 Log\ (1 + vega)_{i,t} + \gamma_k + \delta_t + \tau_t + \varepsilon_i\ , \quad (6)$$

where $CEO\ coauthors'\ ability_i$ is firm i CEO coauthors' average citation to average patent. All other variables are as previously defined. I drop CEOs that are single authors for all the patents. Table 4 presents the first-stage results. I find that CEO coauthors' ability is significant positively related to CEO's innovative abilities in both Panels A and B.[24] Therefore, *CEO coauthors' ability* is a valid instrumental variable since *CEO coauthors' ability* is positively related to CEOs' innovative ability, and CEO coauthors' ability affects firm's innovation only through the CEO.[25]

The second-stage equation estimates the impact of the innovator CEO on the firm's innovation activity:

[24] The results of using the other six measures of a CEO's innovative ability are presented in appendix Table 3A. The results are consistent with Table 4.

[25] One concern regarding the IV maybe that CEOs' free ride and do not really coauthor the patent. To address with this concern, I calculate the frequency with which CEOs and coauthors collaborate. *Frequently collaborated coauthors* are the coauthors have more than one patent with the innovator CEO. The results using *frequently collaborated coauthors* are qualitatively similar to the results in Table 4 and available upon request. I also find that CEO coauthors' ability positively impact firm innovation. The results are available upon request.

$$
\begin{aligned}
&Firm\ innovation_{i,t+1} \\
&\quad = \alpha_1 + \beta_1 \widehat{CEO\ innovative\ ability}_{i,t} + \beta_2 Log(assets)_{i,t} \\
&\quad + \beta_3 Log\ (capital\ intensity)_{i,t} + \beta_4 Stock\ return_{i,t} + \beta_5 Tobin's\ Q_{i,t} \\
&\quad + \beta_6 Log\ (1 + tenure)_{i,t} + \beta_7 CEO\ age_{i,t} + \beta_8 Log\ (1 + delta)_{i,t} \\
&\quad + \beta_9 Log\ (1 + vega)_{i,t} + \gamma_k + \delta_t + \tau_t + \varepsilon_i, \qquad (7)
\end{aligned}
$$

where $\widehat{CEO\ innovative\ ability}_{i,t}$ is the predicted values from equation (6). All other variables are as previously defined.

Table 4 reports the second stage regression results.[26] In Panels A, when a CEO's innovative ability is measured by a dummy variable, there is a significantly positive relation between the firm's innovation and the CEO's innovative ability, suggesting that firms led by innovator CEOs have a greater firm innovation compared to firms led by non-innovator CEOs. In Panel B, a CEO's innovative ability is measured by cumulative average citation. The first-stage results show a positive relation between CEO coauthors' ability and CEOs' innovative ability, consistent with the prediction that people with higher innovative ability are more likely to work with other people with higher innovative ability. The second-stage results show that CEOs' innovative ability has a positive impact on firm innovation. Overall, the results are consistent with hypothesis one that CEOs with innovative ability have a positive effect on the firm's innovation for all the industries.[27]

Consistent with prior literature, Table 4 shows that in general, firm innovation is associated with bigger firms, firms with lower stock return, higher Tobin's Q and younger CEO.

[26] Since only the firms with innovator CEOs have a measured of CEO coauthors' ability, I also run regressions excluding firms led by non-innovator CEOs. The results are available upon request.
[27] The results of using the other six CEO innovative measures are presented in appendix Table 4A.

I also find that in general lower delta value and higher vega value are associated with higher firm innovation consistent with Coles, Naveen and Naveen (2006).

PROPENSITY SCORE MATCHED SAMPLES

Second, I employ a propensity score matching procedure (Rosenbaum and Rubin, 1983) to deal with the endogeneity issue. This methodology allows me to construct a control sample of firms that are led by non-innovator CEOs and exhibit no observable differences in firm and CEO characteristics relative to the firms that are led by innovator CEOs. Therefore, if firm's innovation is different between the matched firms, the only reason can be due to the fact the innovator CEO.

To implement this methodology, I first calculate the probability (propensity score) from the logit regression to construct a nearest-neighbor matched sample for innovator CEOs using all the control variables in equation (5). In each year, I choose, with replacement, the non-innovator CEOs with propensity scores closest to those of each innovator CEO. After constructing the matched sample, I run OLS regression (equation (5)) controlling firm and CEO characteristics, year fixed effects and industry fixed effects. The results are presented in Table 5.[28] Results indicates that innovator CEOs increase firm innovation when measured by patents, citations, average citations per patent and citation-weighted firm innovation, suggesting that firms led by innovator CEOs experience a greater firm innovation compared to firms led by non-innovator CEOs. The results are the same whether there is one or two nearest matching firms.

[28] The propensity score matching characteristics are presented in Table 6A.

EFFECT OF INDUSTRY INNOVATIVENESS

I expect that the effect of an innovator CEO on firm's innovative outcomes should be larger for industries that need innovation the most. I follow Hirshleifer, Low and Teoh (2012) to identify industry innovativeness. Specifically, I identify an industry as an innovative industry if the average citation per patent for the industry is greater than the median average citation per patent across all industries, where industries are classified at the four-digit SIC level.[29] In my sample, the innovative industries have 1,703 innovator CEOs, and non-innovative industries have only 101 innovator CEOs. In order to study the impact of CEOs' innovative ability on innovative industries, I include $Innovative\ industry_i$ defined as a dummy variable equal to one if the firm is in innovative industry and zero otherwise, and the interaction of $Innovator\ CEO_i$ and $Innovative\ industry_i$ as additional independent variables. The results are presented in Table 6. I find that the coefficients of the interaction term between $Innovator\ CEO_i$ and $Innovative\ industry_i$ are negatively significant when firm innovation is measured by firm average citation and citation-weighted firm innovation after controlling for endogeneity. The results do not support hypothesis two and suggest that innovator CEOs in innovative industry lower firm innovation compared to less innovative industry.[30] The results also suggest innovator CEOs' potential overinvestment problem since innovator CEOs have a better opportunity to

[29] The results are robust to classify industries at the two-digit SIC level.
[30] I also study the impact of CEOs' innovative ability on the high-tech industry. I follow Loughran and Ritter's (2004) definition of high-tech industry and non-high-tech industry. I find that innovator CEOs impact firm innovation for both the high-tech and the non-high-tech industry, suggesting that the potential overinvestment problem of innovator CEOs is related to the industry innovativeness and not simply the high-tech industry. The results are available upon request.

invest in R&D projects in innovative industries compared to less innovative industries and then this leads to the overinvestment problem.

THE USEFULNESS OF A CEO'S INNOVATIVE ABILITY TO THE FIRM

Next, I examine why and how innovator CEOs spur firm innovation. Specifically, I ask the question: what kind of innovative ability can spur firm innovation? For example, if a firm led by an innovator CEO is in the retail industry and the innovator CEO has a patent in the health care industry, does this innovative ability spur the high-tech firm's innovation? I expect that if the innovator CEO's innovative ability is more useful for the firm, the effect of the innovator CEO on firm's innovation will be greater. In other words, if the CEO's patent technological classification is the same as the firm's, the CEO's innovative ability is useful for the firm and can spur more firm innovation.

For the firms with innovator CEOs, I split the sample into two subsamples based on CEO patent classification for the technologies to which the patented inventions belong and the firm industry classification.[31] Patent technological classification is from USPTO and Hall et al. (2001).[32] I use Fama-French 12 industry classification as the firm industry classification. I manually matched patent technological classification and firm industry classification. Table 7 presents the results. I find that when a CEO's patent technological classification is the same as

[31] I also split the sample based on CEO patent technological classification and firm patent technological classification. I define firm's patent technological classification but do not count for the CEO's patent. The results remain the same and are available upon request.
[32] USPTO has developed 400 main patent technologies class and over 120,000 patent subclasses. Hall et al. (2001) have developed a higher-level classification and aggregated the 400 classes into 36 two-digit technological sub-categories. And these in turn further aggregated into 6 main categories: Chemical (excluding Drugs); Computers and Communications; Drugs and Medical; Electrical and Electronics; Mechanical; and Others.

the firm industry classification, CEOs' innovative ability has a positive effect on firm average citation and citation-weighted innovation. However, when CEO patent technological classification is not the same as the firm industry classification, the positive coefficients on CEOs' innovative ability disappears after controlling for endogeneity. Surprisingly, the estimated coefficients on CEO's innovative ability are negatively significant when the firm's innovation is measured by citation-weighted firm innovation and patent market-value, suggesting that a CEO's innovative ability hurts the firm's innovation. Further, the equality tests of coefficients show that the differences of CEO cumulative average citation coefficients between the two subsamples are significantly different. This result is also in line with agency theory that innovator CEOs may have overinvestment problem (Jensen and Meckling, 1976) especially when CEOs' innovative ability is not useful for the firm. Overall, the results suggest that innovator CEOs can spur firm innovation only when their patent technological classification is the same as the firm industry classification.[33] In other words, innovator CEOs can spur firm innovation only when the CEO's innovative ability is beneficial for the firm.

R&D SPENDING

I further study how innovator CEOs spur firm innovation by examining the R&D spending. If the innovator CEO values innovation for the firm, then they will invest more in innovative projects. Following Sunder et al. (2017), R&D spending is a measure of innovation

[33] The equality of coefficients tests show that the coefficients between firms where CEO patent technological classification is the same as the firm industry classification and firms CEO patent technological classification is not the same as the firm industry classification are significantly different. The results are available upon request.

input. R&D spending is calculated as the ratio of R&D spending to lagged total assets. If R&D spending is missing, the value is set to zero.

Table 8 displays the results from regressing CEOs' innovative ability on R&D spending. When CEOs' innovative ability is measured by a dummy variable, the estimated coefficients on CEOs' innovative ability are positively significant in both OLS and 2SLS regressions, suggesting that innovator CEOs invest more in firm's innovation activities compared to non-innovator CEOs. When CEOs' innovative ability is measured by the cumulative average citation per patent up to a given year, CEOs' innovative ability is positively significantly related to R&D spending in OLS and 2SLS regressions for the whole sample and the sample excluding firms led by non-innovator CEOs, suggesting that CEOs with higher innovative ability invest more in firm's innovation activities. The results show that innovator CEOs could potentially have overinvestment problems.

INNOVATION EFFICIENCY

Thus far, results indicate that innovator CEOs spur more firm innovation and they spend more on these innovative activities. However, it is not clear if a firm's investments in R&D spending are efficient or not. Therefore, I examine the innovation efficiency for innovator CEOs. Specifically, I estimate the following regression:

$$Firm\ innovation_{i,t+1}$$

$$= \alpha_1 + \beta_1 CEO\ innovative\ ability_{i,t}$$
$$+ \beta_2 CEO\ innovative\ ability * R\&D\ spending_{i,t} + \beta_3 R\&D\ spending_{i,t}$$
$$+ \beta_4 Log(assets)_{i,t} + \beta_5 Log\ (capital\ intensity)_{i,t} + \beta_6 Stock\ return_{i,t}$$
$$+ \beta_7 Tobin's\ Q_{i,t} + \beta_8 Log\ (1 + tenure)_{i,t} + \beta_9 CEO\ age_{i,t}$$
$$+ \beta_{10} Log\ (1 + delta)_{i,t} + \beta_{11} Log\ (1 + vega)_{i,t} + \gamma_k + \delta_t$$
$$+ \varepsilon_i, \qquad (9)$$

Controlling for *CEO innovative ability* and *R&D spending*, the estimated coefficients on the interaction term, $CEO\ innovative\ ability * R\&D\ spending_{i,t}$, stand for the innovation efficiency. All other variables are as previously defined. The results are reported in Table 9. In Panel A, I find that innovator CEO and R&D spending are positively related to firm innovation consistent with previous findings. After controlling for innovator CEO and R&D spending, the interaction term is negatively significant associated with all the firm's innovation measurements in both OLS and 2SLS regressions, suggesting that innovator CEOs do not use R&D funding efficiently to spur firm innovation. In Panel B, CEOs' innovative ability is measured by cumulative citation per patent up to a given year. I find that after controlling for CEOs' innovative ability and R&D spending, the interaction term is negatively significant in both OLS and 2SLS regressions, suggesting that innovator CEOs with greater innovative ability use R&D funding even less efficiently to spur firm innovation. The results are the same for the whole sample and the sample excluding firms led by non-innovator CEOs. The results in Table 9 are consistent with the hypothesis 3 and the agency cost theory that CEOs overinvest in the projects that satisfy their own interests (Jensen and Meckling, 1976; Jensen 1986).

V. INNOVATOR CEO AND FIRM CASH HOLDINGS

In order to understand the negative relation between a CEO's innovative ability and the stock abnormal return on the announcement date of hiring a new innovator CEO, I further investigate the effect of innovator CEOs on firm cash holdings. Following Qiu and Wan (2015), I estimate the regression as below:

$$
\begin{aligned}
Cash_{i,t+1} = {} & \alpha_1 + \beta_1 Innovator\ CEO_{i,t} + \beta_2 Log(sale)_{i,t} + \beta_3 Stock\ return_{i,t} \\
& + \beta_4 Tobin's\ Q_{i,t} + \beta_5 ROA_{i,t} + \beta_6 Sales\ growth_{i,t} \\
& + \beta_7 Income\ volatility_{i,t} + \beta_8 Log\ (1 + delta)_{i,t} + \beta_9 Log\ (1 + vega)_{i,t} + \gamma_k \\
& + \delta_t + \varepsilon_i, \qquad (10)
\end{aligned}
$$

where $Innovator\ CEO_{i,t}$ is a dummy variable equal to one if the CEO had any patents during 1975-2010, $Cash_{i,t+1}$ is the ratio of cash and marketable securities to total book assets, and all other variable definitions are provided in Appendix. Table 10 presents the results from estimating equation (10). In column (1), I do not control for year and industry fixed effects. In column (2), I control for year fixed effect, in column (3), I control for both year and industry fixed effects. I find the coefficients on innovator CEO are positively significant in all three regressions, suggesting that firms led by innovator CEOs hold more cash compared to firms led by non-innovator CEOs.[34] Control variables are consistent with the literature. For example, small

[34] I also find that when CEOs' innovative ability is useful for the frim, firms with innovator CEOs hold less cash compared to firms with non-innovator CEOs. When CEOs' innovative ability is not useful for the firm, firms with innovator CEOs hold more cash compared to firms with non-innovator CEOs, suggesting the agency problems of innovator CEOs.

firms, and firms with lower Tobin's Q and high income volatility hold more cash (Qiu and Wan, 2015).

Next, I compare the value of cash for firms with innovator CEOs and firms with non-innovator CEOs. I follow Faulkender and Wang (2006) to measure cash value and estimate the following regression:

$$r_{i,t} - R^B_{i,t} = \alpha_1 + \beta_1 \frac{\Delta C_{i,t}}{MV_{i,t-1}} + \beta_2 \frac{\Delta E_{i,t}}{MV_{i,t-1}} + \beta_3 \frac{\Delta NA_{i,t}}{MV_{i,t-1}} + \beta_4 \frac{\Delta RD_{i,t}}{MV_{i,t-1}} + \beta_5 \frac{\Delta I_{i,t}}{MV_{i,t-1}}$$
$$+ \beta_6 \frac{\Delta D_{i,t}}{MV_{i,t-1}} + \beta_7 \frac{C_{i,t-1}}{MV_{i,t-1}}_{i,t} + \beta_8 L_{i,t} + \beta_9 \frac{NF_{i,t}}{MV_{i,t-1}}$$
$$+ \varepsilon_i, \qquad (11)$$

The dependent variable, $r_{i,t} - R^B_{i,t}$, is the excess stock return adjusted for size and book-to-market, where $r_{i,t}$ is the stock return for firm i in year t and $R^B_{i,t}$ is the stock i's benchmark return at year t.[35] The benchmark return is the 25 Fama and French (1993) portfolios returns formed on size and book-to-market. The independent variables, $\Delta X_{i,t}$, stand for a change in variable X for firm i over year t-1 to year t. The independent variables include cash and marketable securities ($C_{i,t}$), earnings before extraordinary items ($E_{i,t}$), net assets ($NA_{i,t}$), research and development expense ($RD_{i,t}$), interest expense ($I_{i,t}$), total dividends ($D_{i,t}$), market leverage ($L_{i,t}$) and the firm's net financing ($NF_{i,t}$). The coefficient of cash and marketable securities ($C_{i,t}$), β_1, reflects the cash value of a firm. The dependent variable and all the independent variables (except leverage) are scaled by, $MV_{i,t-1}$, the market value of firm i in year t-1. Therefore, β_1 measures the dollar change in shareholder value when one dollar cash holding changes in a firm.

[35] The yearly stock return is computed using monthly returns from CRSP.

Table 11 presents the results of comparing the cash value between firms with innovation CEOs and firms with non-innovator CEOs. In column (1) and (2), I do not control for year and industry fixed effects. In column (3) and (4), I control for year fixed effect. In column (5) and (6), I control for both year and industry fixed effects. I find that the cash value of firms with innovator CEOs is lower than the firms with non-innovator CEOs in all six regressions. For example, after controlling for year and industry fixed effects, one dollar change in cash holdings results 0.347 dollar change in shareholder values for firms with innovator CEOs. However, the cash value is 0.566 in firms with non-innovator CEOs. The results suggest that the stock market values the cash holdings lower in firms with innovator CEOs than firms with non-innovator CEOs. Although firms with innovator CEOs hold more cash, the cash value is lower, suggesting that firms with innovator CEOs hold excess cash and hurt shareholders' value.

VI. LONG-RUN EFFECTS

In this section, I examine the long-run effects of innovator CEOs on stock return and firm innovation. First, I estimate the following regressions to test the impact of innovator CEOs on firm long-run stock return up to five years after the firm hires the innovator CEO:

$$AR_{0,n}^{i} = \alpha_1 + \beta_1 Innovator\ CEO_{i,t} + \beta_2 Log(sale)_{i,t} + \beta_3 Capital\ intensity_{i,t} + \beta_4 Tobin's\ Q_{i,t} + \beta_5 Log\ (1 + delta)_{i,t} + \beta_6 Log\ (1 + vega)_{i,t} + \gamma_k + \delta_t + \varepsilon_i, \quad (12)$$

where $AR_{0,n}^{i}$ is the buy-and-hold benchmark-adjusted return for firm i for months 1-n after the date of hiring the innovator CEO, r_t^i is the stock raw return for firm i in month t after the date of hiring a new innovator CEO, and r_t^b is the benchmark return in month t. The benchmark returns are CRSP value-weighted index and CRSP equal-weighted index. I calculate the buy-and-hold benchmark-adjusted return of months 1-12 ($AR_{0,1}^{i}$), 1-24 ($AR_{0,2}^{i}$), 1-36 ($AR_{0,3}^{i}$), 1-48 ($AR_{0,4}^{i}$), 1-60 ($AR_{0,5}^{i}$) after firm i hiring the innovator CEO. I also control for industry fixed effects (γ_k) and year fixed effects (δ_t). All the other variables are as previously defined.

Table 12 presents the results from estimating equation (13). I find that CEOs' innovative ability has no impact on stock return for the first two years after the firm hires the innovator CEO. However, firms with innovator CEOs experience greater abnormal buy-and-hold stock return starting the third year of hiring innovator CEOs compared to firms with non-innovator CEOs. The results are consistent with the previous results and the expectation that since innovator CEOs positively impact firm innovation but pose agency problems to the firm, innovator CEOs do not drive firm value in the short-run while drive firm value in the long-run. [36]

Second, I employ 2SLS regressions to investigate the effects of innovator CEOs on firm innovation in the long-run. I estimate regression equation (6)-the first-stage, and equation (7)-the second-stage by changing the dependent variable in the second-stage to firm innovation in the year three ($Firm\ innovation_{i,t+3}$), or firm innovation in the year ten ($Firm\ innovation_{i,t+10}$). Table 13 reports the results. In Panel A, when firm innovation is measured in the year three, firms with innovator CEOs experience greater firm innovation measured in all five proxies. However, the effects of CEOs' innovative ability on firm innovation measured in the year three are smaller compared to when firm innovation is measured in the next year in Table 4 Panel A. In Panel B, firm innovation is measured in the year ten. I find that the innovator CEO still has a positive impact on firm innovation but the effects of innovator CEO on firm innovation are smaller compared to when firm innovation is measured in the year three in Panel A. The results suggest that CEOs' innovation ability can impact firm innovation for up to ten years but the effects of CEOs' innovative ability on firm innovation decrease over time.

[36] The results for the impact of innovator CEOs on stock return around the date of hiring a CEO is in Appendix Table 7A. I find that the stock cumulative abnormal return in the three days window for innovator CEOs is lower than for non-innovator CEOs around the date of hiring an innovator CEO, and that the CEO's innovative ability is negative and statistically significant associated with the abnormal stock return around the date of hiring a new innovator CEO. The results suggest that the market recognizes that innovator CEOs have inefficient overinvestment problems.

VII. ROBUSTNESS TESTS

One concern is that CEOs might use their power to force their name on the patent but not actually be involved in the patent development work. To deal with this concern, I reexamine the effects of CEOs' innovative ability on firm innovation using alternative CEOs' innovative ability measures: CEO cumulative average citations per patent before/after becoming CEO, and CEO cumulative average citations per patent before/after joining the firm. I also test the effects of alternative CEOs' innovative ability measures on firm innovation in difference sample periods: the whole sample, the sample only including the years after hiring the CEO, the sample only inlcuing the year of hiring the CEO, the sample only including the years after the CEO joins the firm, and the sample only including the year that the CEO joins the firm. Regardless of the different measures of CEOs' innovative ability and sample periods used, I find that CEOs' innovative ability positively impacts firm innovation.[37] The results are avaiable upon request.

All the patents a CEO develops while working for a company belong to that company. Thus, there is a possible false positive relation between innovator CEOs and firm innovation. Therefore, I calculate alternative firm innovation measures defined as the difference between firm innovation and CEO innovation that belongs to the firm. Table 14 presents the results. I still find a positive relation between a CEO's innovative ability and the alternative firm innovation, consistent with hypothesis one.

[37] I also find that the effects of *CEO cumulative average citations per patent before becoming CEO* have positive impact on firm innovation for up to ten year after hiring the innovator CEO but the effects decrease over time.

Islam and Zein (2018) argue that innovator CEOs can spur firm innovator because innovator CEOs have the ability to execute innovative investment projects. Specifically, they find that firms with innovator CEOs experience higher new product announcement stock return relative to non-innovator CEOs in the high-tech industry.[38] Since innovator CEOs can also bring agency problems, the overinvestment problems, to the firm, it is possible that innovator CEOs can impact innovative investment projects depending on the level of agency problem. I expect that firms led by innovator CEOs with higher agency problems chase the quantity of patents, while firms led by innovator CEOs with lower agency problems chase better products. Specifically, I expect that the effect of innovator CEOs on new product announcement date stock return is higher for firms with lower agency problem compared to firms with higher agency problem, while the effect of innovator CEOs on firm innovation measured by the quantity of patent is lower for firms with lower agency problem compared to firms with higher agency problem.

The new product announcement stock return data is provided by Mukherjee, Singh and Zaldokas (2017). The new product announcement stock returns are constructed by using textual analysis with event studies on stock market return. They estimate the cumulative abnormal returns over the three-day window around a firm announcing the new product and provide two measurements of the new product announcement stock return: (1) *all product announcement return* is defined as the sum all positive cumulative abnormal returns over the year; and (2) *the number of new products* is defined as the count of the number of announcements with the cumulative abnormal returns above the 75 percentile.

[38] I also find firms with innovator CEOs experience higher new product announcement stock return relative to non-innovator CEOs for all the industries.

I split the sample into firms with higher agency problem and firms with lower agency problem. I define a firm with higher agency problem if the firm's cash holding is higher than the median cash holding level in the industry (two-digit SIC code). I employ 2SLS regressions and estimate regression equation (6)-the first-stage, and equation (7)-the second-stage by changing the dependent variable in the second-stage to new product announcement return measures.[39] The results are presented in Table 15. I find that the effects of innovator CEOs on all product announcement return and the number of new products are higher for firms with lower agency problem. Further, I reexamine Table 4 for firms with higher agency problem and firms with lower agency problem separately.[40] I find that firms led by innovator CEOs with higher agency problem have greater number of patents and citations compared to firms with lower agency problem. The results are consistent with the expectation that firms with lower agency problem produce better products but lower patent quantities.

Another concern is that the CEO's innovative ability is just an alternative measure of the CEO's past industry working experience. To address this, I included past working experience into the regressions. If I can still find a positive relationship between a CEO's innovative ability and the firm innovation, the concern is not valid. Past working experience is calculated as a dummy variable equal to one if the CEO's previous company is in the same industry as his current company industry. Table 16 Panel A show the results, and CEO past working experience is calculated based on a four-digit SIC code.[41] Results indicate that past working experience is negatively related to firm innovation and that a CEO's innovative ability is still positively related

[39] I also control for firm R&D spending.
[40] The results are available upon request.
[41] Results are robust to CEO past working experience calculated based on a two-digit SIC code.

to firm innovation. This suggests that the CEO's innovative ability is not an alternative measure of the CEO's past working experience.

Custodio, Ferreira and Matos (2017) construct a CEO general ability index (GAI) and find that firms with CEOs that have a higher GAI produce more firm innovation. Therefore, it could be that my measure of a CEO's innovative ability is just measuring a CEO's general ability. To address this concern, I add GAI in regression equation (5). GAI is defined as[42]:

$$GAI_{i,t} = 0.268X1_{i,t} + 0.312X2_{i,t} + 0.309X3_{i,t} + 0.218X4_{i,t} + 0.153X5_{i,t}, \quad (13)$$

where X1 is the number of different positions that a CEO has had in his lifetime, X2 is the number of firms where a CEO worked, X3 is the number of industries where a CEO worked, X4 is a dummy variable equal to one if a CEO was a CEO at another firm before the current position, X5 is a dummy variable equal to one if a CEO worked for a multidivisional firm.

Table 16 Panel B presents the results of regression equation (7) adding GAI. I find that GAI is positively related to firm average citation and citation-weighted innovation but negatively related to market-value innovation. After adding GAI into the regression, I still find that a CEO's innovative ability is positively related to firm's innovation, consistent with my hypothesis.

One concern is that the innovative industry overlaps with high-tech industry. I reexamine Table 6 using the innovative industry that are not belong to the high-tech industry. In my sample, the innovative industry not including high-tech industry has 986 innovator CEOs, and non-high-tech industry has 818 innovator CEOs. Specifically, I include ($Innovative\ industry\ not\ including\ hi\_tech_i$) defined as a dummy variable equal to one if the firm is in innovative industries but not in the high-tech industries and zero otherwise, and the

[42] GAI is based on the CEO lifetime publically traded firm working experience prior to the current CEO position.

interaction of $Innovator\ CEO_i$ and ($Innovative\ industry\ not\ including\ hi\_tech_i$) as additional independent variables. The results present in Table 17. The interaction term of $Innovator\ CEO_i$ and ($Innovative\ industry\ not\ including\ hi\_tech_i$) is negatively significant across all the model specifications, suggesting that the negative impact of innovator CEOs on firm innovation in the innovative industry is driven by the innovative industries that are not belong to the high-tech industries.[43]

[43] For example, the professional and commercial equipment (SIC code 5040) industry is in the innovative industry but not high-tech industry and ranks the third for industry average citations per patent among all the industries. Electronic computers (SIC code 3571) is in the innovative industry and also the high-tech industry, and ranks the first for industry average citations per patent among all the industries.

VIII. CONCLUSION

In this paper, I use the CEO's patenting activity to quantify and qualify the CEO's innovative ability. I find that firms led by innovator CEOs experience more firm innovation compared to firms led by non-innovator CEOs. I also find that the greater the CEO's innovative ability, the more innovative the firm is. CEOs' innovative ability has a long-term effect on firm innovation and stock return. Innovator CEOs in the innovative industry lower firm innovation compared to less innovative industry, suggesting the potential overinvestment problem. I also find that innovator CEOs can spur firm innovation only when the CEO's innovative ability is useful for the firm. The effect of CEOs' innovative ability on firm innovation is long-run effect. However, CEOs' innovative ability that benefit firm innovation may not be without a cost. Although firms with innovator CEOs spend more on R&D projects, the innovative efficiency is lower compared to firms with non-innovator CEOs. Furthermore, firms with innovator CEOs hold more cash than firms with non-innovator CEOs but have a lower cash value. Overall, the results suggest that innovator CEOs spur firm innovation but pose agency problems to the firm. The results are also robust to the alternative measurement of CEOs' innovative ability and firm innovation, the CEO's past working experience and the CEO's general ability.

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APPENDIX

APPENDIX 1: Year and Industry Distribution

Table 1

Year and Industry Distribution

This table provides the breakdown of the number of non-innovator CEOs, number of innovator CEOs, and the percentage of innovator CEOs in the sample by year (Panel A) and by industry excluding financial firms and utilities (Panel B and C). The sample of CEOs is from ExecuComp for the period of 1992-2008.

Panel A: Distribution by Year

Year	Non-Innovator CEOs (#)	Innovator CEOs (#)	Innovator CEOs (%)
1992	210	17	7.5%
1993	617	45	6.8%
1994	879	91	9.4%
1995	943	102	9.8%
1996	982	114	10.4%
1997	1,022	127	11.1%
1998	1,044	127	10.8%
1999	1,093	145	11.7%
2000	1,086	127	10.5%
2001	1,033	125	10.8%
2002	1,016	121	10.6%
2003	1,024	127	11.0%
2004	1,047	119	10.2%
2005	1,038	104	9.1%
2006	1,070	99	8.5%
2007	1,191	110	8.5%
2008	1,182	104	8.1%
Total	16,477	1,804	9.9%

Panel B: Distribution by Fama-French 12 Industry Groups

Industry	Non-Innovator CEOs (#)	Innovator CEOs (#)	Innovator CEO Patent's Industry = Firm's Industry (#)	Innovator CEOs (%)
Consumer NonDurables	1,319	55	21	4.0%
Consumer Durables	193	34	7	15.0%
Manufacturing	2,869	341	161	10.6%
Enrgy	1,112	19	6	1.7%
Chems	796	82	54	9.3%
Business Equipment	3,233	662	489	17.0%
Shops	2,097	72	0	3.3%
Health	1,564	262	254	14.3%
Other	3,294	277	65	7.8%
Total	16,477	1,804	1,057	9.9%

Panel C: Distribution by High-tech Industry Following Loughran and Ritter (2004)

Industry	Non-Innovator CEOs (#)	Innovator CEOs (#)	Innovator CEO Patent's Industry = Firm's Industry (#)	Innovator CEOs (%)
High-tech	3,264	717	546	18.0%
None high-tech	13,213	1,087	511	7.6%
Total	16,477	1,804	1,057	9.9%

APPENDIX 2: Summary Statistics

Table 2

Summary Statistics

This table presents summary statistics of the variables used in this study. T-tests (Wilcoxon-Mann-Whitney tests) are conducted to test for differences between the means (medians) for firms with innovator CEOs and non-innovator CEOs. Variable definitions are provided in the Appendix. *, ** and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Non-Innovator CEOs				Innovator CEOs			
Variable	N	Mean	Median	Std. Dev.	N	Mean	Median	Std. Dev.
Dependent variables								
Firm patent	16477	28.44	0.00	151.10	1804	39.91***	4.00***	153.87
Firm citation	16477	299.64	0.00	2171.25	1804	409.99**	15.50***	1786.61
Firm avg. citation	16477	4.51	0.00	11.92	1804	9.97***	2.21***	23.81
Citation-weighted firm innovation	16477	57.86	0.00	321.39	1804	92.51***	8.13***	344.48
Market-value firm innovation	16477	460.47	0.00	2923.97	1804	823.62***	9.69***	4814.34
R&D spending	16477	4.38	0.75	8.84	1804	8.58***	5.92***	11.07
Independent variables								
CEO patent	16477	0	0	0	1804	0.82***	0	4.04
CEO citation	16477	0	0	0	1804	12.21***	0	67.20
CEO avg. citation	16477	0	0	0	1804	4.74***	0	27.03
CEO cumulative patent	16477	0	0	0	1804	9.86***	2.00***	26.59
CEO cumulative citation	16477	0	0	0	1804	260.14***	40.00***	673.71
CEO cumulative avg. citation	16477	0	0	0	1804	26.20***	15.00***	41.44
CEO total cumulative avg. citation	16477	0	0	0	1804	23.75***	14.17***	30.27
Assets (millions)	16475	4862.07	1008.01	18725.46	1804	5490.38	607.74***	45216.52
Capital intensity	16274	172.03	37.10	879.16	1797	60.13***	37.97**	79.52
Stock return (%)	16287	0.80	0.04	21.21	1792	0.57	0.02	12.14
Tobin's Q	14965	2.30	1.68	2.53	1659	2.93***	2.13***	3.45
Tenure (months)	16477	78.35	48.00	85.30	1804	107.05***	72.00***	103.17
CEO age (years)	16422	55.43	56.00	7.63	1802	55.25	55.00	8.31
Delta	13725	1010.61	186.34	10052.47	1629	3651.61***	226.02***	26658.81
Vega	14288	105.01	37.23	235.46	1664	121.05**	33.51**	320.34

APPENDIX 3: Innovator CEOs and firm's innovation

Table 3

Innovator CEOs and firm's innovation--OLS results

This table presents the effects of innovator CEOs on firm's innovation from OLS regressions. Panel A presents CEO's innovative ability measured by *Innovator CEO*, which is a dummy variable equal to one if the CEO had any patents during 1975-2010. Panel B presents CEO's innovative ability measured by *CEO cumulative avg. citation*, which is the ratio of CEO cumulative citation over CEO cumulative patent. *Firm patent* is the number of patent the firm applied in a given year. *Firm citation* is the number of citations subsequently received by the patents the firm applied in a given year. *Firm avg. citation* is the ratio of firm citations over firm patents. *Citation-weighted firm innovation* is the sum of the weight of citations on each patent plus one for firm i in time t divided by book assets of firm i in year t. *Market-value firm innovation* is total dollar value of innovation produced by firm i in year t divided by book assets of firm i in year t. All independent variables are lagged by 1 year. Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

Panel A: CEOs' innovative ability measured by innovator CEO

	Log (1+ firm patent)		Log (1+ firm citation)		Firm avg. citation		Citation-weighted firm innovation		Market-value firm innovation	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Innovator CEO	0.560***	0.0268	0.877***	0.0811	3.872***	2.369***	49.01***	20.21**	325.2***	-112.1
	(15.58)	(0.96)	(15.94)	(1.41)	(12.06)	(4.53)	(5.49)	(3.21)	(4.34)	(-1.18)
Log (assets)	0.452***	0.203***	0.538***	0.250***	0.0736	-1.034***	66.63***	18.50***	671.4***	308.6***
	(46.89)	(15.68)	(36.39)	(9.39)	(0.85)	(-4.26)	(27.78)	(6.34)	(33.37)	(6.99)
Log (capital intensity)	-0.0329**	0.0158	-0.0555**	0.0868**	-0.0866	0.0473	0.387	-6.447*	73.06**	-43.15
	(-2.81)	(1.05)	(-3.09)	(2.81)	(-0.83)	(0.17)	(0.13)	(-1.91)	(2.99)	(-0.84)
Stock return	-0.00300**	-0.000121	-0.00459**	-0.000837	-0.0178*	-0.0564**	-0.183	0.0697	-6.873**	-20.45***
	(-2.87)	(-0.10)	(-2.87)	(-0.34)	(-1.91)	(-2.53)	(-0.71)	(0.26)	(-3.16)	(-5.03)
Tobin's Q	0.104***	0.00728**	0.167***	0.0371***	0.551***	0.329***	5.973***	-0.475	171.0***	105.2***
	(19.74)	(2.23)	(20.56)	(5.53)	(11.65)	(5.37)	(4.54)	(-0.65)	(15.50)	(9.45)
Log (1+tenure)	-0.00405	-0.00399	-0.000545	-0.00544	-0.147*	-0.0651	0.214	-2.588**	-28.03	-49.00**
	(-0.45)	(-0.81)	(-0.04)	(-0.54)	(-1.85)	(-0.71)	(0.10)	(-2.35)	(-1.50)	(-2.94)
CEO age	-0.0118***	0.000813	-0.0148***	0.00486**	-0.0357**	0.0228	-2.206***	0.272	-6.989**	5.252
	(-7.65)	(0.76)	(-6.23)	(2.21)	(-2.58)	(1.13)	(-5.73)	(1.13)	(-2.16)	(1.44)
Log (1+delta)	-0.00819	0.00159	-0.00807	-0.00587	0.250**	-0.0660	2.940	1.626	81.01***	123.8***
	(-0.90)	(0.25)	(-0.58)	(-0.45)	(3.07)	(-0.55)	(1.30)	(1.13)	(4.27)	(5.70)
Log(1+vega)	0.107***	0.00369	0.149***	-0.0187	0.399***	-0.216*	2.083	0.569	-37.13**	-86.78***
	(12.77)	(0.61)	(11.63)	(-1.52)	(5.35)	(-1.92)	(1.00)	(0.42)	(-2.13)	(-4.24)
Year fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm fixed effects	N	Y	N	Y	N	Y	N	Y	N	Y
Adjusted R-square	0.397	0.895	0.373	0.804	0.145	0.348	0.101	0.872	0.161	0.611
Observations	13913	13913	13913	13913	13913	13913	13913	13913	13913	13913

Panel B: CEOs' innovative ability measured by CEO cumulative avg. citation

	Log (1+ firm patent)		Log (1+ firm citation)		Firm avg. citation		Citation-weighted firm innovation		Market-value firm innovation	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
CEO cumulative avg. citation	0.00947***	0.00200***	0.0194***	0.00735***	0.201***	0.175***	0.582**	0.270**	2.166	1.127
	(12.11)	(4.24)	(16.25)	(7.58)	(29.58)	(20.11)	(3.00)	(2.54)	(1.33)	(0.70)
Log (assets)	0.447***	0.203***	0.535***	0.251***	0.183**	-0.996***	65.90***	18.56***	664.8***	308.9***
	(46.26)	(15.72)	(36.23)	(9.47)	(2.18)	(-4.17)	(27.50)	(6.36)	(33.07)	(7.00)
Log (capital intensity)	-0.0326**	0.0152	-0.0568**	0.0844**	-0.137	-0.00366	0.509	-6.284*	74.53**	-45.33
	(-2.78)	(1.01)	(-3.16)	(2.74)	(-1.34)	(-0.01)	(0.17)	(-1.86)	(3.05)	(-0.89)
Stock return	-0.00294**	-0.000106	-0.00447**	-0.000810	-0.0165*	-0.0551**	-0.180	0.0978	-6.862**	-20.64***
	(-2.80)	(-0.09)	(-2.80)	(-0.33)	(-1.82)	(-2.51)	(-0.69)	(0.36)	(-3.15)	(-5.08)
Tobin's Q	0.105***	0.00710**	0.166***	0.0365***	0.518***	0.313***	6.041***	-0.511	171.9***	105.2***
	(19.69)	(2.18)	(20.44)	(5.45)	(11.23)	(5.21)	(4.59)	(-0.69)	(15.57)	(9.45)
Log (1+tenure)	0.00115	-0.00463	0.00679	-0.00789	-0.136*	-0.121	0.714	-2.595**	-24.41	-49.98**
	(0.13)	(-0.95)	(0.50)	(-0.79)	(-1.74)	(-1.34)	(0.32)	(-2.35)	(-1.31)	(-2.99)
CEO age	-0.0115***	0.000944	-0.0139***	0.00534**	-0.0232*	0.0343*	-2.198***	0.295	-7.060**	5.291
	(-7.41)	(0.88)	(-5.87)	(2.43)	(-1.72)	(1.73)	(-5.70)	(1.22)	(-2.18)	(1.45)
Log (1+delta)	-0.00587	0.000779	-0.00820	-0.00901	0.154*	-0.137	3.348	1.677	85.12***	122.1***
	(-0.64)	(0.12)	(-0.59)	(-0.69)	(1.94)	(-1.17)	(1.48)	(1.17)	(4.48)	(5.63)
Log(1+vega)	0.108***	0.00428	0.151***	-0.0166	0.424***	-0.165	2.140	0.652	-36.98**	-86.49***
	(12.85)	(0.71)	(11.80)	(-1.35)	(5.83)	(-1.49)	(1.03)	(0.48)	(-2.12)	(-4.22)
Year fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Firm fixed effects	N	Y	N	Y	N	Y	N	Y	N	Y
Adjusted R-square	0.393	0.895	0.373	0.805	0.187	0.368	0.100	0.872	0.160	0.611
Observations	13913	13913	13913	13913	13913	13913	13913	13913	13913	13913

APPENDIX 4: Innovator CEOs and firm's innovation 2sls results

Table 4

Innovator CEOs and firm's innovation--2SLS results

This table presents the effects of innovator CEOs on firm's innovation from 2SLS regressions. Instrumental variable is CEO coauthors' ability calculated as CEO coauthors' average citation over average patent. CEO coauthors' patents do not include the patents cooperated with the CEO. The odd number columns show the results on the whole sample. The even number columns present the results only including innovator CEOs. All independent variables are lagged by 1 year. In Panel A, CEOs' innovative ability is measured by a dummy variable equal to one if the CEO had any patents during 1975-2010. In Panel B, CEOs' innovative ability is measured by the ratio of CEO cumulative citations over CEO cumulative patents. Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

Panel A: CEOs' innovative ability measured by innovator CEO

	First-stage	Log (1+ firm patent)	Log (1+ firm citation)	Firm avg. citation	Citation-weighted firm innovation	Market-value firm innovation
		(1)	(2)	(3)	(4)	(5)
Innovator CEO		0.253***	1.578***	0.710***	92.55***	337.5**
		(4.97)	(16.06)	(14.84)	(5.76)	(2.50)
CEO coauthors' ability	0.0203***					
	(77.24)					
Log (assets)	-0.00271	0.204***	0.541***	0.104***	67.56***	673.5***
	(-0.82)	(15.67)	(36.29)	(14.30)	(27.71)	(32.91)
Log (capital intensity)	0.00719*	0.00393	-0.0755***	-0.0296***	-0.885	70.36**
	(1.88)	(0.26)	(-4.17)	(-3.35)	(-0.30)	(2.83)
Stock return	-0.000356	-0.000384	-0.00445**	-0.00193**	-0.182	-6.925**
	(-1.18)	(-0.32)	(-2.78)	(-2.48)	(-0.70)	(-3.15)
Tobin's Q	0.000213	0.00686**	0.167***	0.0679***	6.128***	173.5***
	(0.26)	(2.10)	(20.49)	(17.12)	(4.60)	(15.52)
Log (1+tenure)	-0.00191	-0.00602	0.0120	0.00438	0.438	-27.16
	(-1.53)	(-1.22)	(0.87)	(0.65)	(0.19)	(-1.43)
CEO age	0.00121***	0.00132	-0.0158***	-0.00413***	-2.268***	-7.001**
	(4.40)	(1.21)	(-6.61)	(-3.55)	(-5.80)	(-2.13)
Log (1+delta)	0.00501**	-0.000180	-0.0194	-0.00548	2.502	84.59***
	(3.09)	(-0.03)	(-1.38)	(-0.80)	(1.08)	(4.37)
Log(1+vega)	0.00146	0.00360	0.142***	0.0536***	1.686	-40.09**
	(0.95)	(0.60)	(10.95)	(8.49)	(0.80)	(-2.25)
Year fixed effects	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y
Firm fixed effects	Y	Y	Y	Y	Y	Y
Adjusted R-square	0.783	0.911	0.832	0.445	0.890	0.665
Observations	13671	13,671	13,671	13,671	13,671	13,671

Panel B: CEOs' innovative ability measured by CEO cumulative avg. citation

	First-stage	Log (1+ firm patent)	Log (1+ firm citation)	Firm avg. citation	Citation-weighted firm innovation	Market-value firm innovation
		(1)	(2)	(3)	(4)	(5)
CEO cumulative avg. citation		0.00469***	0.00834***	0.0501***	1.087***	1.285
		(0.000943)	(0.00194)	(0.0172)	(0.215)	(3.262)
CEO coauthors' ability	1.099***					
	(0.0165)					
Log (assets)	-0.428**	0.205***	0.252***	-0.951***	18.76***	311.5***
	(0.206)	(0.0130)	(0.0267)	(0.237)	(2.964)	(44.93)
Log (capital intensity)	-0.134	0.00638	0.0787**	0.229	-6.159*	-47.37
	(0.239)	(0.0151)	(0.0310)	(0.275)	(3.441)	(52.16)
Stock return	-0.0890***	-5.65e-05	-0.000778	-0.0554**	0.0887	-20.84***
	(0.0189)	(0.00119)	(0.00244)	(0.0216)	(0.271)	(4.108)
Tobin's Q	0.115**	0.00637*	0.0364***	0.342***	-0.587	106.1***
	(0.0519)	(0.00327)	(0.00673)	(0.0595)	(0.746)	(11.31)
Log (1+tenure)	-0.00465	-0.00648	-0.00644	0.0397	-2.829**	-49.43***
	(0.0783)	(0.00493)	(0.0102)	(0.0898)	(1.125)	(17.06)
CEO age	0.0254	0.00151	0.00520**	-0.00506	0.336	5.737
	(0.0173)	(0.00109)	(0.00224)	(0.0198)	(0.248)	(3.756)
Log (1+delta)	0.274***	-0.000197	-0.00960	0.0118	1.336	123.1***
	(0.101)	(0.00641)	(0.0132)	(0.117)	(1.461)	(22.15)
Log(1+vega)	-0.162*	0.00474	-0.0178	-0.214*	0.702	-90.15***
	(0.0960)	(0.00605)	(0.0125)	(0.110)	(1.381)	(20.94)
Year fixed effects	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y
Firm fixed effects	Y		Y	Y	Y	Y
Adjusted R-square	0.682	0.382	0.363	0.314	0.097	0.160
Observations	13,671	13671	13671	13671	13671	13671

APPENDIX 5: Innovator CEOs and firm's innovation Propensity score matching results

Table 5

Innovator CEOs and firm's innovation--Propensity score matching results

This table presents the effects of innovator CEOs on firm's innovation from propensity score matching results. *Firm patent* is the number of patent the firm applied in a given year. *Firm citation* is the number of citations subsequently received by the patents the firm applied in a given year. *Firm avg. citation* is the ratio of firm citations over firm patents. *Citation-weighted firm innovation* is the sum of the weight of citations on each patent plus one for firm i in time t divided by book assets of firm i in year t. *Firm avg. citation* is the ratio of firm citations over firm patents. *Market-value firm innovation* is total dollar value of innovation produced by firm i in year t divided by book assets of firm i in year t. All independent variables are lagged by 1 year. Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

	Log (1+ firm patent)		Log (1+ firm citation)		Firm avg. citation		Citation-weighted firm innovation		Market-value firm innovation	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Innovator CEO	0.625***	0.646***	0.989***	0.957***	0.470***	0.485***	15.56**	16.43***	-1.831	1.824
	(12.58)	(14.23)	(13.79)	(12.20)	(11.63)	(13.23)	(3.06)	(3.32)	(-0.04)	(0.04)
Nearest matching	1	2	1	2	1	2	1	2	1	2
Other control variables	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	3,006	4,509	3,006	4,509	3,006	4,509	3,006	4,509	3,006	4,509

APPENDIX 6: Effect of industry innovativeness

Table 6

Effect of industry innovativeness

This table presents the effects of innovator CEOs on firm's innovation. An innovative industry follows Hirshleifer, Low and Teoh (2012) and is equal to one if the average citation per patent for the industry is greater than the median average citation per patent across all industries. *Innovator CEO* is a dummy variable equal to one if the CEO has any patents during 1975-2010 *Firm avg. citation* is the ratio of firm citations over firm patents. *Citation-weighted firm innovation* is the sum of the weight of citations on each patent plus one for firm i in time t divided by book assets of firm i in year t. *Market-value firm innovation* is total dollar value of innovation produced by firm i in year t divided by book assets of firm i in year t. All independent variables are lagged by 1 year. Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

	Firm avg. citation		Citation-weighted firm innovation		Market-value firm innovation	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
Innovator CEO	0.571	101.0***	32.05	837.7**	236.8	-1761.5
	(0.46)	(7.78)	(0.92)	(2.54)	(0.81)	(-0.64)
Innovator CEO * Innovative industry	3.097**	-97.44***	12.75	-781.5**	65.09	2139.8
	(2.42)	(-7.51)	(0.36)	(-2.37)	(0.22)	(0.78)
Innovative industry	3.859***	6.423***	49.17***	69.85***	269.2***	217.7**
	(13.75)	(14.10)	(6.26)	(6.03)	(4.08)	(2.27)
Log (assets)	0.0907	0.177*	66.82***	67.97***	672.5***	677.7***
	(1.06)	(1.82)	(27.90)	(27.58)	(33.44)	(33.14)
Log (capital intensity)	-0.0528	-0.152	0.847	-0.207	75.59**	77.95**
	(-0.51)	(-1.29)	(0.29)	(-0.07)	(3.10)	(3.12)
Stock return	-0.0146	-0.0126	-0.142	-0.135	-6.646**	-6.774**
	(-1.58)	(-1.21)	(-0.55)	(-0.51)	(-3.05)	(-3.09)
Tobin's Q	0.511***	0.516***	5.477***	5.593***	168.3***	169.8***
	(10.86)	(9.72)	(4.16)	(4.15)	(15.24)	(15.18)
Log (1+tenure)	-0.111	-0.106	0.678	-0.287	-25.50	-26.54
	(-1.40)	(-1.18)	(0.31)	(-0.12)	(-1.37)	(-1.39)
CEO age	-0.0343**	-0.0170	-2.189***	-1.991***	-6.896**	-6.768**
	(-2.50)	(-1.08)	(-5.69)	(-4.95)	(-2.14)	(-2.03)
Log (1+delta)	0.271***	0.381***	3.208	3.944*	82.48***	82.32***
	(3.35)	(4.12)	(1.42)	(1.68)	(4.35)	(4.22)
Log(1+vega)	0.288***	0.282***	0.717	1.007	-44.60**	-46.26**
	(3.87)	(3.33)	(0.34)	(0.47)	(-2.55)	(-2.59)
Year fixed effects	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y
Adjusted R-square	0.158	0.167	0.104	0.081	0.162	0.161
Observations	13913	13671	13913	13671	13913	13671

APPENDIX 7: The usefulness of CEO's innovative ability to the firm

Table 7

The usefulness of CEO's innovative ability to the firm

This table presents the usefulness of CEO's innovative ability to the firm. *CEO cumulative avg. citation* is the ratio of CEO cumulative citation over CEO cumulative patent. *Firm avg. citation* is the ratio of firm citations over firm patents. *Citation-weighted firm innovation* is the sum of the weight of citations on each patent plus one for firm i in time t divided by book assets of firm i in year t. *Market-value firm innovation* is total dollar value of innovation produced by firm i in year t divided by book assets of firm i in year t. All independent variables are lagged by 1 year. Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

	(1) CEO patent technological classification = firm industry classification						**(2) CEO patent technological classification not equal to firm industry classification**					
	Firm avg. citation		Citation-weighted firm innovation		Market-value firm innovation		Firm avg. citation		Citation-weighted firm innovation		Market-value firm innovation	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
CEO cumulative avg. citation	0.232***	0.281***	0.187	3.084***	-1.922	6.363	0.156***	0.030	-0.777*	-2.307	-11.45**	-45.01**
	(13.28)	(7.11)	(0.90)	(5.51)	(-0.94)	(1.27)	(6.90)	(0.45)	(-1.84)	(-1.45)	(-2.30)	(-2.30)
Log (assets)	-0.450	-0.0740	73.13***	93.92***	622.8***	702.6***	-0.492	0.118	121.8***	150.4***	1291.5***	1552.5***
	(-0.72)	(-0.11)	(9.86)	(10.29)	(8.58)	(8.60)	(-0.97)	(0.26)	(12.86)	(13.89)	(11.55)	(11.65)
Log (capital intensity)	0.212	0.383	-3.889	-11.92	-173.9*	-185.3*	0.932	0.982	9.396	-23.52	157.6	-180.4
	(0.24)	(0.44)	(-0.37)	(-0.96)	(-1.71)	(-1.67)	(1.11)	(1.18)	(0.60)	(-1.20)	(0.86)	(-0.75)
Stock return	-0.124**	-0.122**	-0.150	-0.101	-29.65***	-29.87***	-0.400	0.416	-15.15	-26.02	-355.8*	-419.7*
	(-2.07)	(-2.11)	(-0.21)	(-0.12)	(-4.24)	(-4.08)	(-0.47)	(0.52)	(-0.96)	(-1.40)	(-1.91)	(-1.83)
Tobin's Q	0.550*	0.635**	1.758	3.138	181.6***	182.5***	0.199	0.590	-0.263	10.22	62.96	214.2**
	(1.83)	(2.16)	(0.49)	(0.75)	(5.16)	(4.89)	(0.56)	(1.63)	(-0.04)	(1.20)	(0.81)	(2.04)
Log (1+tenure)	-2.155***	-1.617**	-3.167	2.385	16.91	20.27	-2.078***	-0.532	7.879	4.660	66.75	-14.01
	(-3.76)	(-2.72)	(-0.46)	(0.28)	(0.25)	(0.27)	(-4.14)	(-1.15)	(0.84)	(0.43)	(0.60)	(-0.10)
CEO age	0.0242	0.00302	-4.831***	-5.474***	-17.88*	-20.98**	0.317**	0.0772	-9.360***	-7.229**	-95.12***	-79.60**
	(0.29)	(0.04)	(-4.76)	(-4.58)	(-1.80)	(-1.96)	(3.12)	(0.76)	(-4.95)	(-3.03)	(-4.25)	(-2.71)
Log (1+delta)	0.735	1.017*	15.54**	13.59*	322.9***	360.8***	0.368	0.882*	65.78***	86.02***	750.9***	1000.4***
	(1.35)	(1.88)	(2.39)	(1.77)	(5.07)	(5.24)	(0.78)	(1.88)	(7.50)	(7.80)	(7.24)	(7.36)
Log(1+vega)	0.766	0.669	2.562	-1.967	-2.081	-13.10	0.906**	0.0467	-57.27***	-75.70***	-680.9***	-990.9***
	(1.44)	(1.26)	(0.40)	(-0.26)	(-0.03)	(-0.19)	(2.32)	(0.11)	(-7.87)	(-7.64)	(-7.92)	(-8.12)
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
Adjusted R-square	0.320	0.348	0.206	0.028	0.255	0.265	0.172	0.172	0.447	0.518	0.446	0.475
Observations	885	788	885	788	885	788	613	468	613	468	613	468

The equality tests of coefficients	Firm avg. citation		Citation-weighted firm innovation		Market-value firm innovation	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
The differences of CEO cumulative avg. citation coefficients between (1) and (2)	0.076	0.250***	0.964**	5.389***	9.528*	51.373***
The equality tests (Wald test)	0.63	7.73	4.76	9.00	2.80	6.65

APPENDIX 8: Innovator CEOs and firm's R&D spending

Table 8

Innovator CEOs and firm's R&D spending

This table presents the effects of innovator CEOs on firm's R&D spending. Column (1) and (2) presents CEO's innovative ability measured by *Innovator CEO*, which is a dummy variable equal to one if the CEOs have any patent in their life. Column (3) to (5) presents CEO's innovative ability measured by *CEO cumulative avg. citation*, which is the ratio of CEO cumulative citation over CEO cumulative patent. All independent variables are lagged by 1 year. Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

Dependent variable: R&D spending	CEO innovative ability measured by: Innovator CEO		CEO innovative ability measured by: CEO cumulative avg. citation		
	OLS	2SLS	OLS	2SLS	2SLS
	(1)	(2)	(3)	(4)	(5)
CEO innovative ability	1.978***	4.172***	0.035***	0.093***	0.065***
	(9.16)	(10.98)	(7.47)	(10.92)	(2.91)
Log (assets)	-1.597***	-1.572***	-1.614***	-1.569***	-2.258***
	(-27.80)	(-26.91)	(-28.10)	(-26.72)	(-9.30)
Log (capital intensity)	0.581***	0.568***	0.581***	0.554***	1.475***
	(8.35)	(8.08)	(8.33)	(7.84)	(4.10)
Stock return	-0.006	-0.007	-0.006	-0.006	0.143***
	(-1.02)	(-1.10)	(-0.98)	(-1.00)	(5.14)
Tobin's Q	0.379***	1.378***	1.379***	1.375***	0.901***
	(43.58)	(43.19)	(43.54)	(42.86)	(7.00)
Log (1+tenure)	0.087	0.081	0.104**	0.118**	0.708***
	(1.63)	(1.52)	(1.96)	(2.19)	(3.14)
CEO age	-0.069***	-0.063***	-0.068***	-0.062***	-0.254***
	(-7.56)	(-6.75)	(-7.40)	(-6.63)	(-6.85)
Log (1+delta)	-0.262***	-0.310***	-0.255***	-0.321***	-0.032
	(-4.85)	(-5.67)	(-4.72)	(-5.82)	(-0.15)
Log(1+vega)	0.895***	0.928***	0.897***	0.932***	0.834***
	(18.12)	(18.51)	(18.16)	(18.50)	(4.35)
Year fixed effects	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y
Adjusted R-square	0.2801	0.4304	0.2787	0.4245	0.5878
Observations	14356	14114	14356	14114	1261

APPENDIX 9: Innovator CEOs and firm's innovation efficiency

Table 9

Innovator CEOs and firm's innovation efficiency

This table presents The effects of innovator CEOs on firm's innovation efficiency. Dependent variable *R&D* spending is the ratio of R&D to lagged total assets, expressed as a percentage. Panel A presents CEO's innovative ability measured by *Innovator CEO*, which is a dummy variable equal to one if the CEOs have any patent in their life. Panel B presents CEO's innovative ability measured by *CEO cumulative avg. citation*, which is the ratio of CEO cumulative citation over CEO cumulative patent. *Firm patent* is the number of patent the firm applied in a given year. *Firm citation* is the number of citations subsequently received by the patents the firm applied in a given year. *Citation-weighted firm innovation* is the sum of the weight of citations on each patent plus one for firm i in time t divided by book assets of firm i in year t. *Firm avg. citation* is the ratio of firm citations over firm patents. *Market-value firm innovation* is total dollar value of innovation produced by firm i in year t divided by book assets of firm i in year t. All independent variables are lagged by 1 year. Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

Panel A: CEOs' innovative ability measured by innovator CEO

	Log (1+ firm patent)		Log (1+ firm citation)		Firm avg. citation		Citation-weighted firm innovation		Market-value firm innovation	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Innovator CEO	0.698***	1.269***	1.054***	2.170***	4.480***	0.951***	56.17***	118.9***	400.8***	336.5*
	(16.81)	(13.73)	(16.43)	(15.19)	(11.61)	(13.47)	(5.22)	(4.96)	(4.44)	(1.67)
Innovator CEO x R&D spending	-0.0282***	-0.0497***	-0.0373***	-0.0802***	-0.114***	-0.0318***	-1.813**	-3.984***	-16.27**	-11.55
	(-9.79)	(-11.81)	(-8.38)	(-12.31)	(-4.28)	(-9.88)	(-2.43)	(-3.65)	(-2.60)	(-1.26)
R&D spending	0.0490***	0.0513***	0.0682***	0.0730***	0.177***	0.0271***	4.015***	4.280***	30.49***	30.03***
	(36.17)	(36.25)	(32.54)	(33.32)	(14.07)	(25.06)	(11.43)	(11.65)	(10.34)	(9.74)
Log (assets)	0.528***	0.533***	0.643***	0.654***	0.341***	0.146***	72.94***	74.39***	718.6***	723.6***
	(55.80)	(55.40)	(44.02)	(43.94)	(3.89)	(19.86)	(29.78)	(29.77)	(34.94)	(34.51)
Log (capital intensity)	-0.0549***	-0.0588***	-0.0864***	-0.0900***	-0.164	-0.0337***	-1.511	-1.852	59.13**	58.47**
	(-4.90)	(-5.18)	(-4.99)	(-5.13)	(-1.57)	(-3.88)	(-0.52)	(-0.63)	(2.43)	(2.37)
Stock return	-0.000938	-0.00104	-0.00171	-0.00187	-0.0105	-0.000998	-0.0108	-0.0246	-5.583**	-5.643**
	(-0.94)	(-1.04)	(-1.11)	(-1.20)	(-1.13)	(-1.30)	(-0.04)	(-0.09)	(-2.57)	(-2.58)
Tobin's Q	0.0609***	0.0603***	0.106***	0.104***	0.395***	0.0445***	2.331*	2.329*	143.8***	145.3***
	(11.72)	(11.48)	(13.18)	(12.77)	(8.19)	(11.07)	(1.73)	(1.71)	(12.72)	(12.69)
Log (1+tenure)	-0.00636	-0.00763	-0.00389	-0.00428	-0.155*	-0.00269	-0.0104	-0.554	-29.56	-32.15*
	(-0.75)	(-0.88)	(-0.29)	(-0.32)	(-1.95)	(-0.41)	(-0.00)	(-0.25)	(-1.59)	(-1.70)
CEO age	-0.00845***	-0.00829***	-0.00998***	-0.00954***	-0.0240*	-0.00167	-1.908***	-1.879***	-4.828	-4.252
	(-5.69)	(-5.51)	(-4.35)	(-4.10)	(-1.74)	(-1.45)	(-4.96)	(-4.81)	(-1.49)	(-1.30)
Log (1+delta)	-0.00905	-0.0157*	-0.00934	-0.0204	0.247**	-0.00591	2.850	2.456	80.42***	84.63***
	(-1.04)	(-1.78)	(-0.70)	(-1.49)	(3.06)	(-0.87)	(1.27)	(1.07)	(4.25)	(4.39)
Log(1+vega)	0.0637***	0.0640***	0.0889***	0.0878***	0.245**	0.0342***	-1.457	-1.559	-63.83***	-65.96***
	(7.92)	(7.80)	(7.15)	(6.92)	(3.27)	(5.45)	(-0.70)	(-0.73)	(-3.65)	(-3.69)
Year fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Adjusted R-square	0.450	0.444	0.418	0.408	0.157	0.333	0.110	0.109	0.168	0.169
Observations	13913	13671	13913	13671	13913	13671	13913	13671	13913	13671

Panel B: CEOs' innovative ability measured by CEO cumulative avg. citation

	Log (1+ firm patent)			Log (1+ firm citation)			Firm avg. citation			Citation-weighted firm innovation			Market-value firm innovation		
	OLS	2SLS	2SLS	OLS	2SLS	2SLS	OLS	2SLS	2SLS	OLS	2SLS	2SLS	OLS	2SLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
CEO cumulative avg. citation	0.0104***	0.0210***	0.0160***	0.0211***	0.0362***	0.0334***	0.218***	0.0164***	0.0144***	0.608**	2.123***	2.209**	2.361	7.020**	-6.982
	(12.93)	(13.50)	(4.94)	(17.08)	(15.14)	(6.13)	(30.07)	(13.92)	(5.28)	(2.92)	(5.27)	(3.02)	(1.35)	(2.08)	(-0.89)
CEO cumulative avg. citation x R&D spending	-0.0002***	-0.0003***	-0.0002***	-0.0004***	-0.0005***	-0.0004***	-0.002***	-0.0002***	-0.0002***	-0.0158**	-0.0318***	-0.0357***	-0.119**	-0.168**	-0.110
	(-10.08)	(-12.78)	(-5.55)	(-10.07)	(-12.57)	(-5.61)	(-8.98)	(-10.08)	(-4.27)	(-2.61)	(-4.49)	(-3.83)	(-2.34)	(-2.83)	(-1.11)
R&D spending	0.0471***	0.0473***	0.0328***	0.0658***	0.0659***	0.0416***	0.165***	0.0243***	0.0111**	3.937***	4.006***	6.589***	29.57***	30.24***	42.24***
	(36.76)	(36.41)	(7.59)	(33.36)	(33.13)	(5.71)	(14.31)	(24.88)	(3.06)	(11.89)	(11.94)	(6.74)	(10.63)	(10.75)	(4.05)
Log (assets)	0.527***	0.538***	0.656***	0.645***	0.661***	0.734***	0.454***	0.149***	0.0856**	72.57***	74.83***	133.4***	714.9***	726.2***	1175.4***
	(55.55)	(55.38)	(19.62)	(44.25)	(44.37)	(13.03)	(5.31)	(20.34)	(3.04)	(29.62)	(29.81)	(17.66)	(34.76)	(34.51)	(14.56)
Log (capital intensity)	-0.0579***	-0.0657***	0.0277	-0.0919***	-0.101***	0.0700	-0.221**	-0.0385***	0.0424	-1.616	-2.477	-10.44	58.57**	56.33**	-115.5
	(-5.15)	(-5.76)	(0.59)	(-5.31)	(-5.79)	(0.88)	(-2.18)	(-4.47)	(1.07)	(-0.56)	(-0.84)	(-0.98)	(2.40)	(2.28)	(-1.02)
Stock return	-0.000829	-0.000825	-0.00111	-0.00154	-0.00151	-0.00880	-0.00950	-0.000843	-0.00717**	-0.00238	-0.00362	1.178	-5.527**	-5.562**	-17.78**
	(-0.83)	(-0.82)	(-0.30)	(-1.00)	(-0.97)	(-1.43)	(-1.05)	(-1.11)	(-2.33)	(-0.01)	(-0.01)	(1.42)	(-2.54)	(-2.54)	(-2.01)
Tobin's Q	0.0603***	0.0592***	0.0393**	0.104***	0.102***	0.0827**	0.370***	0.0437***	0.0420**	2.319*	2.204	-4.798	144.0***	144.4***	116.9**
	(11.57)	(11.20)	(2.30)	(12.98)	(12.60)	(2.86)	(7.86)	(10.97)	(2.91)	(1.72)	(1.61)	(-1.24)	(12.73)	(12.60)	(2.83)
Log (1+tenure)	-0.00355	-0.00296	-0.0174	0.000260	0.00438	-0.0367	-0.151*	0.00158	-0.0368	0.317	-0.0228	-5.913	-27.39	-30.69	-35.35
	(-0.42)	(-0.34)	(-0.60)	(0.02)	(0.33)	(-0.75)	(-1.96)	(0.24)	(-1.51)	(0.14)	(-0.01)	(-0.90)	(-1.48)	(-1.63)	(-0.50)
CEO age	-0.00751***	-0.00741***	-0.0354***	-0.00836***	-0.00813***	-0.0456***	-0.0103	-0.00110	-0.0103**	-1.858***	-1.806***	-5.122***	-4.506	-4.027	-32.37**
	(-5.05)	(-4.89)	(-7.24)	(-3.65)	(-3.50)	(-5.54)	(-0.76)	(-0.97)	(-2.51)	(-4.83)	(-4.62)	(-4.64)	(-1.40)	(-1.23)	(-2.75)
Log (1+delta)	-0.00893	-0.0190**	0.151***	-0.0126	-0.0259*	0.202***	0.138*	-0.00834	0.0603**	3.113	2.118	39.79***	83.35***	83.23***	594.2***
	(-1.02)	(-2.13)	(5.55)	(-0.94)	(-1.89)	(4.40)	(1.75)	(-1.24)	(2.62)	(1.38)	(0.92)	(6.45)	(4.40)	(4.30)	(9.02)
Log(1+vega)	0.0652***	0.0657***	0.0421*	0.0917***	0.0910***	0.114**	0.279***	0.0357***	0.0760***	-1.417	-1.424	-42.23***	-63.70***	-66.21***	-512.2***
	(8.07)	(7.96)	(1.70)	(7.39)	(7.19)	(2.73)	(3.84)	(5.73)	(3.64)	(-0.68)	(-0.67)	(-7.54)	(-3.64)	(-3.70)	(-8.56)
Year fixed effects	Y	Y	Y	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	Y	Y	Y
Adjusted R-square	0.447	0.437	0.420	0.420	0.411	0.310	0.201	0.344	0.324	0.109	0.106	0.329	0.167	0.167	0.396
Observations	13913	13671	1256	13913	13671	1256	13913	13671	1256	13913	13671	1256	13913	13671	1256

APPENDIX 10: Innovator CEO and firm cash holdings

Table 10

Innovator CEO and firm cash holdings

This table presents the results from OLS regression of innovator CEO and firm cash holdings. Innovator CEO is a dummy variable equal to one if the CEO has any patents during 1975-2010. The dependent variable is the ratio of cash and marketable securities to total book assets. All other variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

	(1)	(2)	(3)
Innovator CEO	0.0437***	0.0450***	0.0378***
	(10.01)	(10.47)	(8.82)
Log(sale)	-0.0513***	-0.0500***	-0.0496***
	(-49.32)	(-48.36)	(-47.80)
Tobin's Q	0.0197***	0.0209***	0.0194***
	(25.34)	(26.95)	(25.29)
Stock return	-0.00134	-0.00211*	-0.00190
	(-1.07)	(-1.70)	(-1.56)
Log(ROA)	-0.0761***	-0.0673***	-0.0631***
	(-9.24)	(-8.26)	(-7.85)
Sale growth	-0.0001	-0.0001	-0.0001
	(-0.40)	(-0.46)	(-0.54)
Income volatility	0.0001***	0.0001***	0.0001***
	(13.20)	(12.73)	(12.73)
Log (1+delta)	0.0118***	0.0109***	0.0104***
	(11.31)	(10.61)	(10.10)
Log(1+vega)	0.0134***	0.00839***	0.00840***
	(14.11)	(8.57)	(8.68)
Year fixed effects	N	Y	Y
Industry fixed effects	N	Y	Y
Adjusted R-square	0.308	0.328	0.350
Observations	12003	12003	12003

APPENDIX 11: Innovator CEO and cash value

Table 11

Innovator CEO and cash value

This table presents the results from OLS regression of innovator CEO and cash value. The dependent variable is the excess stock return adjusted for size and book-to-market calculated as the stock return for firm i in year t subtracts the stock i's benchmark return at year t. The benchmark return is the 25 Fama and French (1993) portfolios returns formed on size and book-to-market. The independent variables include cash and marketable securities, earnings before extraordinary items, net assets, research and development expense, interest expense, total dividends, market leverage and the firm's net financing. All the independent variables (except leverage) are scaled by the market value of firm i in year t-1. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

	Firms with innovator CEOs	Firms with non-innovator CEOs	Firms with innovator CEOs	Firms with non-innovator CEOs	Firms with innovator CEOs	Firms with non-innovator CEOs
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta C_{i,t}$	0.319***	0.560***	0.332***	0.559***	0.347***	0.566***
	(3.87)	(17.29)	(3.87)	(17.03)	(4.04)	(17.16)
$\Delta E_{i,t}$	-0.00864	0.0179***	-0.0108	0.0179***	-0.0176	0.0183***
	(-0.08)	(3.68)	(-0.10)	(3.67)	(-0.16)	(3.74)
$\Delta NA_{i,t}$	0.239***	0.0132**	0.244***	0.0128**	0.247***	0.0118**
	(5.90)	(2.28)	(5.92)	(2.19)	(5.97)	(2.01)
$\Delta RD_{i,t}$	-0.220	0.968***	-0.220	0.962***	-0.306	0.991***
	(-1.14)	(11.50)	(-1.12)	(11.35)	(-1.54)	(11.42)
$\Delta I_{i,t}$	-4.282***	-0.0781**	-4.427***	-0.0760**	-4.328***	-0.0728**
	(-5.96)	(-2.63)	(-6.00)	(-2.55)	(-5.87)	(-2.43)
$\Delta D_{i,t}$	-0.901	0.0239	-1.122	0.0458	-1.175	0.0578
	(-0.87)	(0.09)	(-1.05)	(0.17)	(-1.10)	(0.22)
$C_{i,t-1}$	0.225***	0.579***	0.245***	0.578***	0.255***	0.584***
	(3.99)	(18.50)	(4.22)	(18.24)	(4.39)	(18.34)
$L_{i,t}$	-0.180**	-0.251***	-0.193**	-0.261***	-0.212**	-0.263***
	(-2.46)	(-7.73)	(-2.61)	(-7.94)	(-2.81)	(-7.92)
$NF_{i,t}$	0.0166	-0.0220	-0.00234	-0.0171	0.0137	-0.0122
	(0.14)	(-0.70)	(-0.02)	(-0.54)	(0.11)	(-0.38)
Year fixed effects	N	N	Y	Y	Y	Y
Industry fixed effects	N	N	N	N	Y	Y
Adjusted R-square	692	6524	692	6524	692	6524
Observations	0.089	0.080	0.095	0.081	0.099	0.082

APPENDIX 12: Innovator CEO and Long-run Stock Performance

Table 12

Innovator CEO and Long-run Stock Performance

This table presents the results from OLS regression of the effects of innovator CEOs on stock long-run performance. The dependent variables are buy-and-hold benchmark-adjusted return of months 1-12 (AR0,1), 1-24 (AR0,2), 1-36 (AR0,3), 1-48 (AR0,4), and 1-60 (AR0,5) after the announcement date of hiring a new innovator CEO. The benchmark returns are CRSP value-weighted index (marke_vw adj.) and CRSP equal-weighted index (market-ew adj.). Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

	AR0,1 (market-vw adj.)	AR0,1 (market-ew adj.)	AR0,2 (market-vw adj.)	AR0,2 (market-ew adj.)	AR0,3 (market-vw adj.)	AR0,3 (market-ew adj.)	AR0,4 (market-vw adj.)	AR0,4 (market-ew adj.)	AR0,5 (market-vw adj.)	AR0,5 (market-ew adj.)
Innovator CEO	4.451	2.887	16.25	12.58	38.60*	29.18	79.02**	59.81*	101.7**	72.12**
	(0.70)	(0.46)	(1.38)	(1.06)	(1.88)	(1.40)	(2.51)	(1.88)	(2.92)	(2.02)
Log (assets)	-8.753***	-8.986***	-15.33***	-15.29***	-22.94***	-22.18***	-28.85***	-26.37***	-35.38***	-30.45***
	(-5.61)	(-5.79)	(-5.31)	(-5.28)	(-4.55)	(-4.34)	(-3.75)	(-3.38)	(-4.15)	(-3.48)
Log (capital intensity)	0.00208	0.0000320	0.00504	-0.00184	0.0154	0.00202	0.0199	0.00837	0.0330	0.0136
	(0.22)	(0.00)	(0.29)	(-0.11)	(0.51)	(0.07)	(0.43)	(0.18)	(0.65)	(0.26)
Tobin's Q	1.012	0.984	3.438**	3.470**	8.594***	8.478***	20.14***	20.28***	12.94***	13.27***
	(1.41)	(1.38)	(2.60)	(2.61)	(3.72)	(3.62)	(5.70)	(5.67)	(3.31)	(3.30)
Log (1+delta)	7.306***	7.335***	14.45***	14.37***	26.02***	25.78***	50.05***	47.78***	61.72***	56.01***
	(4.11)	(4.14)	(4.39)	(4.35)	(4.53)	(4.42)	(5.70)	(5.38)	(6.35)	(5.61)
Log(1+vega)	-0.336	-0.0150	-2.435	-1.202	-1.878	-0.410	-16.40*	-14.03	-24.78**	-22.23**
	(-0.18)	(-0.01)	(-0.70)	(-0.34)	(-0.31)	(-0.07)	(-1.77)	(-1.50)	(-2.42)	(-2.11)
Year fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Adjusted R-square	0.037	0.044	0.051	0.055	0.062	0.061	0.083	0.077	0.068	0.056
Observations	1376	1376	1376	1376	1376	1376	1376	1376	1376	1376

APPENDIX 13: Innovator CEOs and long-run firm's innovation

Table 13

Innovator CEOs and long-run firm's innovation

This table presents the effects of CEOs' innovative ability on firm's long-run innovation from 2SLS regressions. Panel A presents the results when firm innovation is measured in three years. Panel A presents the results when firm innovation is measured in ten years. Instrumental variable is *CEO coauthors' ability* calculated as CEO coauthors' average citation over average patent. CEO coauthors' patents do not include the patents cooperated with the CEO. Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

Panel A: Firm innovation in year three

	Log (1+ firm patent) (t+3)	Log (1+ firm citation) (t+3)	Firm avg. citation (t+3)	Citation-weighted firm innovation (t+3)	Market-value firm innovation (t+3)
	(1)	(2)	(3)	(4)	(5)
Innovator CEO	0.658***	0.979***	0.425***	67.44***	248.3*
	(10.40)	(10.75)	(10.93)	(4.07)	(1.84)
Log (assets)	0.419***	0.488***	0.111***	67.31***	648.5***
	(42.73)	(34.58)	(18.43)	(26.21)	(30.93)
Log (capital intensity)	-0.0381**	-0.0629***	-0.0225**	0.532	95.60***
	(-3.22)	(-3.69)	(-3.10)	(0.17)	(3.78)
Stock return	-0.00232**	-0.00445**	-0.00162**	-0.201	-5.214**
	(-2.22)	(-2.95)	(-2.52)	(-0.73)	(-2.33)
Tobin's Q	0.107***	0.143***	0.0485***	6.723***	145.0***
	(20.08)	(18.62)	(14.81)	(4.81)	(12.71)
Log (1+tenure)	0.00834	0.0201	0.00922*	1.164	-25.86
	(0.92)	(1.55)	(1.66)	(0.49)	(-1.34)
CEO age	-0.00916***	-0.00957***	-0.00182*	-2.405***	-6.254*
	(-5.84)	(-4.24)	(-1.89)	(-5.86)	(-1.87)
Log (1+delta)	0.000752	-0.000328	0.000967	5.896**	83.53***
	(0.08)	(-0.02)	(0.17)	(2.44)	(4.23)
Log(1+vega)	0.0730***	0.0850***	0.0279***	-2.164	-36.97**
	(8.61)	(6.97)	(5.36)	(-0.98)	(-2.04)
Year fixed effects	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y
Adjusted R-square	13671	13671	13671	13671	13671
Observations	0.359	0.322	0.275	0.091	0.147

Panel B: Firm innovation in year ten

	Log (1+ firm patent) (t+10)	Log (1+ firm citation) (t+10)	Firm avg. citation (t+10)	Citation-weighted firm innovation (t+10)	Market-value firm innovation (t+10)
	(1)	(2)	(3)	(4)	(5)
Innovator CEO	0.136**	0.161**	0.0427***	10.34	-34.82
	(3.00)	(3.26)	(3.30)	(0.85)	(-0.45)
Log (assets)	0.183***	0.177***	0.0308***	30.11***	241.5***
	(26.06)	(23.12)	(15.39)	(15.91)	(20.20)
Log (capital intensity)	-0.0416***	-0.0507***	-0.0140***	0.151	21.79
	(-4.93)	(-5.50)	(-5.78)	(0.07)	(1.51)
Stock return	-0.000996	-0.000803	-0.000149	-0.151	-2.014
	(-1.33)	(-0.98)	(-0.70)	(-0.75)	(-1.58)
Tobin's Q	0.0348***	0.0319***	0.00642***	4.634***	56.70***
	(9.12)	(7.67)	(5.89)	(4.50)	(8.72)
Log (1+tenure)	0.0261***	0.0287***	0.00689***	3.385*	15.79
	(4.03)	(4.07)	(3.73)	(1.94)	(1.43)
CEO age	-0.00333**	-0.00360**	-0.000928**	-0.983**	-2.768
	(-2.97)	(-2.94)	(-2.90)	(-3.25)	(-1.45)
Log (1+delta)	-0.00205	-0.00964	-0.000378	-0.881	2.470
	(-0.31)	(-1.34)	(-0.20)	(-0.49)	(0.22)
Log(1+vega)	0.00402	0.00573	0.000103	-0.363	-7.489
	(0.66)	(0.87)	(0.06)	(-0.22)	(-0.73)
Year fixed effects	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y
Adjusted R-square	13671	13671	13671	13671	13671
Observations	0.212	0.195	0.186	0.044	0.077

APPENDIX 14: Alternative firm innovation measure

Table 14

Alternative firm innovation measure

This table presents the effects of innovator CEOs on alternative firm innovation measure. Column (1) and (2) present dependent variable measured as firm patent subtract CEO patent. Column (3) and (4) present dependent variable measured as firm citation subtract CEO citation. Column (5) and (6) present dependent variable measured as firm average citation subtract CEO average citation. All independent variables are lagged by 1 year. Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

	(Frim patent - CEO patent)		(Firm citation - CEO citation)		(Firm avg. citation - CEO avg. citation)	
	OLS (1)	2SLS (2)	OLS (3)	2SLS (4)	OLS (5)	2SLS (6)
Innovator CEO	17.38***	24.77***	108.0*	349.0***	3.241***	7.061***
	(4.22)	(3.40)	(1.87)	(3.42)	(10.45)	(13.37)
Log (assets)	32.23***	32.70***	299.3***	309.2***	0.150*	0.285***
	(29.15)	(28.98)	(19.29)	(19.53)	(1.80)	(3.48)
Log (capital intensity)	0.532	0.315	6.691	2.202	-0.187*	-0.228**
	(0.40)	(0.23)	(0.36)	(0.12)	(-1.85)	(-2.31)
Stock return	-0.0990	-0.103	-0.833	-0.892	-0.0172*	-0.0172**
	(-0.83)	(-0.86)	(-0.50)	(-0.53)	(-1.90)	(-1.97)
Tobin's Q	3.447***	3.497***	34.21***	34.20***	0.542***	0.529***
	(5.69)	(5.70)	(4.02)	(3.97)	(11.86)	(11.87)
Log (1+tenure)	0.571	0.372	20.32	16.78	-0.0719	-0.0223
	(0.56)	(0.36)	(1.41)	(1.15)	(-0.93)	(-0.29)
CEO age	-0.998***	-0.981***	-10.47***	-10.17***	-0.0365**	-0.0340**
	(-5.63)	(-5.44)	(-4.21)	(-4.02)	(-2.73)	(-2.59)
Log (1+delta)	1.696	1.618	5.930	1.344	0.230**	0.184**
	(1.63)	(1.52)	(0.41)	(0.09)	(2.92)	(2.38)
Log(1+vega)	-0.221	-0.272	12.77	12.38	0.351***	0.318***
	(-0.23)	(-0.28)	(0.95)	(0.90)	(4.87)	(4.49)
Year fixed effects	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y
Adjusted R-square	0.111	0.112	0.059	0.058	0.145	0.141
Observations	13913	13671	13913	13671	13913	13671

APPENDIX 15: Innovator CEOs and New Product Announcement

Table 15

Innovator CEOs and New Product Announcement

This table presents the effects of innovator CEOs on new product announcement stock return from 2SLS regressions. *All product announcement return* is defined as the sum all positive cumulative abnormal returns over the year. *The number of new products* is defined as the count of the number of announcements with the cumulative abnormal returns above the 75 percentile. A firm is defined as a firm with higher agency problem if the firm's cash holding is higher than the median cash holding level in the industry (two-digit SIC code). Instrumental variable is CEO coauthors' ability calculated as CEO coauthors' average citation over average patent. Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

	Dependent variable: All product announcement return		Dependent variable: The number of new products	
	More cash holding	Less cash holding	More cash holding	Less cash holding
	(1)	(2)	(3)	(4)
Innovator CEO	0.0580**	0.186***	0.892**	2.508***
	(1.97)	(5.84)	(2.17)	(5.81)
R&D spending	0.00458***	0.00489***	0.0611***	0.0650***
	(6.17)	(6.56)	(5.92)	(6.41)
Log (assets)	0.0599***	0.0310***	0.841***	0.412***
	(10.31)	(7.19)	(10.41)	(7.02)
Log (capital intensity)	-0.0239**	-0.00373	-0.273**	-0.0453
	(-2.80)	(-0.61)	(-2.30)	(-0.55)
Stock return	-0.0140***	0.00110	-0.163**	0.0333
	(-3.50)	(0.68)	(-2.94)	(1.51)
Tobin's Q	0.0118***	-0.00518*	0.119***	-0.104**
	(4.68)	(-1.74)	(3.39)	(-2.56)
Log (1+tenure)	-0.00528	-0.00959**	-0.0912	-0.136**
	(-0.98)	(-2.29)	(-1.22)	(-2.39)
CEO age	-0.00125	-0.00236**	-0.0158	-0.0307**
	(-1.31)	(-3.18)	(-1.19)	(-3.05)
Log (1+delta)	0.0373***	0.0246***	0.546***	0.334***
	(6.70)	(5.49)	(7.07)	(5.48)
Log(1+vega)	-0.0230***	0.000382	-0.296***	0.0184
	(-4.63)	(0.09)	(-4.29)	(0.31)
Year fixed effects	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y
Adjusted R-square	1521	1355	1521	1355
Observations	0.247	0.173	0.241	0.164

APPENDIX 16: Innovator CEO, CEO past working experience and general ability index

Table 16

Innovator CEO, CEO past working experience and general ability index

This table presents the effects of innovator CEOs, CEO past working experience and general ability index on firm's innovation. *Past working experience* is equal to one if the CEO worked in the same industry in the past. Panel A presents the results that CEO past working experience based on four-digit SIC code. Panel B presents the effects of innovator CEOs and general ability index on firm's innovation. *General ability index* is from Custodio, Ferreira and Matos (2017). *Firm avg. citation* is the ratio of firm citations over firm patents. *Citation-weighted firm innovation* is the sum of the weight of citations on each patent plus one for firm i in time t divided by book assets of firm i in year t. *Market-value firm innovation* is total dollar value of innovation produced by firm i in year t divided by book assets of firm i in year t. All other independent variables are lagged by 1 year. Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

Panel A: CEO past working experience based on four-digit SIC code.

	Firm avg. citation		Citation-weighted firm innovation		Market-value firm innovation	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
Innovator CEO	3.879***	7.691***	49.64***	92.60***	332.8***	349.2**
	(12.08)	(13.99)	(5.56)	(5.85)	(4.44)	(2.63)
Past working experience	-0.487	-0.747	-40.23**	-44.69**	-477.3**	-488.3**
	(-0.75)	(-1.17)	(-2.22)	(-2.44)	(-3.14)	(-3.18)
Log (assets)	0.0741	0.208**	66.66***	68.21***	671.9***	676.3***
	(0.86)	(2.45)	(27.80)	(27.85)	(33.40)	(32.93)
Log (capital intensity)	-0.0807	-0.110	0.871	0.389	78.81**	78.95**
	(-0.77)	(-1.07)	(0.30)	(0.13)	(3.22)	(3.18)
Stock return	-0.0178*	-0.0179**	-0.184	-0.193	-6.877**	-6.967**
	(-1.91)	(-1.97)	(-0.71)	(-0.74)	(-3.16)	(-3.18)
Tobin's Q	0.551***	0.537***	5.969***	5.941***	171.0***	172.8***
	(11.65)	(11.61)	(4.54)	(4.46)	(15.50)	(15.47)
Log (1+tenure)	-0.151*	-0.104	-0.0508	-0.715	-31.17*	-33.59*
	(-1.88)	(-1.33)	(-0.02)	(-0.32)	(-1.67)	(-1.77)
CEO age	-0.0357**	-0.0333**	-2.208***	-2.124***	-7.006**	-6.471**
	(-2.58)	(-2.45)	(-5.74)	(-5.43)	(-2.17)	(-1.97)
Log (1+delta)	0.249**	0.209**	2.866	2.401	80.13***	83.56***
	(3.06)	(2.60)	(1.27)	(1.04)	(4.22)	(4.32)
Log(1+vega)	0.400***	0.363***	2.201	2.258	-35.74**	-36.99**
	(5.37)	(4.94)	(1.06)	(1.07)	(-2.05)	(-2.08)
Year fixed effects	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y
Adjusted R-square	45	0.140	0.101	0.102	0.162	0.163
Observations	13913	13671	13913	13671	13913	13671

Panel B: CEO general ability index.

	Firm avg. citation		Citation-weighted firm innovation		Market-value firm innovation	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(4)	(5)	(7)	(8)
Innovator CEO	4.128***	8.102***	52.27***	95.79***	341.9***	400.8**
	(11.57)	(13.34)	(5.04)	(5.21)	(3.97)	(2.62)
General ability index	0.165	0.207*	2.827	3.237	-56.13*	-61.38**
	(1.35)	(1.72)	(0.80)	(0.89)	(-1.91)	(-2.03)
Log (assets)	-0.0734	0.0571	72.75***	74.29***	725.8***	733.3***
	(-0.75)	(0.60)	(25.63)	(25.64)	(30.79)	(30.48)
Log (capital intensity)	-0.0704	-0.106	0.241	-0.295	69.97**	69.83**
	(-0.60)	(-0.93)	(0.07)	(-0.09)	(2.47)	(2.43)
Stock return	-0.0642	-0.0571	-1.637	-1.639	-58.64***	-59.58***
	(-1.56)	(-1.43)	(-1.37)	(-1.36)	(-5.90)	(-5.94)
Tobin's Q	0.611***	0.600***	6.828***	6.868***	213.0***	216.0***
	(11.13)	(11.22)	(4.28)	(4.24)	(16.09)	(16.07)
Log (1+tenure)	-0.228**	-0.161*	-0.713	-1.397	-43.28**	-46.82**
	(-2.56)	(-1.86)	(-0.28)	(-0.53)	(-2.01)	(-2.14)
CEO age	-0.0315**	-0.0295*	-2.695***	-2.593***	-5.190	-4.264
	(-1.98)	(-1.90)	(-5.85)	(-5.52)	(-1.36)	(-1.09)
Log (1+delta)	0.268**	0.247**	4.319	4.169	96.54***	101.1***
	(2.91)	(2.73)	(1.61)	(1.53)	(4.34)	(4.46)
Log(1+vega)	0.385***	0.331***	-0.623	-0.735	-46.53**	-48.36**
	(4.53)	(3.95)	(-0.25)	(-0.29)	(-2.27)	(-2.30)
Year fixed effects	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y
Adjusted R-square	0.149	0.145	0.107	0.108	0.173	0.174
Observations	11489	11262	11489	11262	11489	11262

APPENDIX 17: Effect of industry innovativeness not including high-tech industry

Table 17

Effect of industry innovativeness not including high-tech industry

This table presents the effects of innovator CEOs on firm's innovation. The definition of high-tech industry follows Loughran and Ritter (2004). An innovative industry is equal to one if the average citation per patent for the industry is greater than the median average citation per patent across all industries. *Innovator CEO* is a dummy variable equal to one if the CEO has any patents during 1975-2010 *Firm avg. citation* is the ratio of firm citations over firm patents. *Citation-weighted firm innovation* is the sum of the weight of citations on each patent plus one for firm i in time t divided by book assets of firm i in year t. *Market-value firm innovation* is total dollar value of innovation produced by firm i in year t divided by book assets of firm i in year t. All independent variables are lagged by 1 year. Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

	Firm avg. citation		Citation-weighted firm innovation		Market-value firm innovation	
	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)
Innovator CEO	4.705***	11.06***	89.17***	145.0***	666.7***	552.9**
	(10.27)	(12.17)	(6.96)	(5.52)	(6.19)	(2.51)
Innovator CEO * Innovative industry (not including hi-tech)	-2.239***	-8.156***	-81.85***	-126.8***	-668.3***	-540.4**
	(-3.76)	(-8.51)	(-4.92)	(-4.58)	(-4.78)	(-2.32)
Innovative industry (not including hi-tech)	4.042***	3.885***	51.89***	51.12***	289.8***	292.6***
	(14.63)	(14.35)	(6.71)	(6.54)	(4.46)	(4.46)
Log (assets)	0.107	0.261**	67.47***	68.95***	677.8***	679.4***
	(1.25)	(3.07)	(28.15)	(28.03)	(33.68)	(32.89)
Log (capital intensity)	-0.0493	-0.0843	0.824	0.273	75.34**	75.72**
	(-0.47)	(-0.83)	(0.28)	(0.09)	(3.09)	(3.06)
Stock return	-0.0149	-0.0162*	-0.156	-0.174	-6.764**	-6.821**
	(-1.61)	(-1.79)	(-0.60)	(-0.67)	(-3.11)	(-3.11)
Tobin's Q	0.511***	0.504***	5.480***	5.515***	168.3***	170.3***
	(10.88)	(10.93)	(4.17)	(4.14)	(15.25)	(15.24)
Log (1+tenure)	-0.111	-0.0676	0.627	-0.0116	-25.92	-27.81
	(-1.41)	(-0.86)	(0.28)	(-0.01)	(-1.39)	(-1.47)
CEO age	-0.0317**	-0.0256*	-2.092***	-2.006***	-6.103*	-5.960*
	(-2.30)	(-1.88)	(-5.44)	(-5.11)	(-1.89)	(-1.81)
Log (1+delta)	0.249**	0.176**	2.369	1.923	75.61***	82.45***
	(3.07)	(2.19)	(1.05)	(0.83)	(3.98)	(4.24)
Log(1+vega)	0.292***	0.259***	0.798	0.777	-43.97**	-46.20**
	(3.93)	(3.52)	(0.38)	(0.37)	(-2.52)	(-2.59)
Year fixed effects	Y	Y	Y	Y	Y	Y
Industry fixed effects	Y	Y	Y	Y	Y	Y
Adjusted R-square	0.158	0.150	0.105	0.105	0.164	0.164
Observations	13913	13671	13913	13671	13913	13671

PART 2: TALENT CYCLING IN IPOS

I. INTRODUCTION

Talent cycling in IPOs refers to the job seeking behavior in high-tech firms where talented patent inventors leave once an IPO is successful and then pursue another job at a private firm.[44] This phenomenon is common in Silicon Valley and a headache for many companies that go public.[45] For example, Google expressed this concern at the time of their IPO in 2004. One of the risk factors in their prospectus said that "The initial option grants to many of our senior management and key employees are fully vested. Therefore, these employees may not have sufficient financial incentives to stay with us." Bernstein (2015) finds that the patent inventors in IPO firms are 18% more likely to leave and 14% more likely to generate new start-ups after the firm completes an IPO compared to firms that withdraw their IPO filing and stay private. Campbell, Ganco, Franco and Agarwal (2012) also find that employees with greater pay (presumably the more talented employees) are more likely to leave and create a new venture within the same industry than join another established firm. Previous literature finds that the outflow of talent is associated with lower revenue growth (Batt, 2002), reduced operating performance (Ton and Huckman, 2008; and Hancock, Allen, Bosco, McDaniel and Pierce, 2013), and decreased firm innovation after an IPO (Bernstein, 2015). This paper examines the

[44] Talent cycling is a subset of inventor mobility. Inventor Mobility, as defined in the previous literature (Marx, Strumsky, and Fleming, 2009; and Chemmanur, Kong, Krishnan and Yu, 2015), refers to patent inventors who move to another firm which can be public or private.
[45] This article addresses talent cycling is a headache for many companies. https://www.paysa.com/blog/twilio-tech-talent-evolution-from-pre-ipo-to-post-ipo/

outflow of talented tech workers after IPOs to explain the underperformance of post-IPOs, which has puzzled academics for the last twenty years.

Ritter (1991) finds that IPO firms underperform compared to a sample of size- and industry-matched seasoned firms for up to three years post IPO. Researchers have proposed many explanations for this puzzle. It has been proposed that non-venture-backed IPOs (Brav and Gompers, 1997) and IPO firms without prestigious underwriters (Carter, Dark and Singh, 1998), poorer quality underwriters (Dong, Michel and Pandes, 2011) or less prestigious venture capital providers (Krishnan, Ivanov, Masulis and Singh, 2011) experience lower post-IPO long-run performance. Researchers also find that IPO firms with unusually high accruals in the IPO year (Teoh, Welch and Wong, 1998) and acquired within a year of going public (Brau, Couch and Sutton, 2012) experience poor stock return performance. Another string of literature explains IPO underperformance from the control of management perspective. For example, Jain and Kini (1994) find that firms with management that retains a larger portion ownership experience better post-IPO performance. Kroll, Walters and Le (2007) find that firms with original top management team members controlling a firm's board have a better post-IPO performance.

Human capital is also a non-negligible factor for IPO performance. Lippman and Rumelt (1982) and Coff (1997) propose that human capital is the source of a firm's competitive advantage. Barney (1991) indicates that a firm's competitive advantage is banked on the talent and expertise of employees. Chemmanur and Paeglis (2005) study the relations between the quality of a firm's management and IPO long-run performance and measure management quality from three dimensions including management team resources, team structure and management reputation outside of the business community. They find that firms with better managers have greater long-term stock returns. Chemmanur, Kong, Krishnan and Yu (2015) study the effects of management quality and inventor mobility on firm innovation. They find that firms with higher management quality are associated with greater firm innovation by hiring more and higher quality inventors. Kaiser, Kongsted and Ronde (2015) also find that inventor mobility increases firm innovation. Bernstein (2015) examines inventor mobility and firm innovation by comparing firms that go public versus firms that withdraw their IPO filing. He finds that after an IPO, a firm's innovation decreases, in part because more inventors leave the firm. However, none of these studies examine the impact of the outflow of talent on IPO long-run performance.

The sample includes 884 IPO firms that had patents one year before the IPO date from 1985 to 2007.[46] In my sample, I find that 11% of patent inventors have the talent cycling behavior. [47] Specifically, 15.3% of patent inventors left their IPO firms within one year after an IPO (leavers). Among the 15.3% of leavers, 72% of patent inventors joined non-public companies (cyclers) and 28% of patent inventors joined public companies (non-cyclers). Comparing cyclers and non-cyclers, I find that on average, cyclers' patents and citations are significantly greater than those of non-cycler, and that within a firm, cyclers also have more patents and citations than non-cyclers. Furthermore, cyclers are even better than the newly hired inventors (newcomers). Within one year after an IPO, the number of newcomers is greater than the number of cyclers, but the quality of newcomers is lower than that of the cyclers. Therefore, cyclers tend to be the most talented employees in the firm. [48]

To examine the phenomenon of talent cycling, a patent inventor is defined as a cycler if the inventor has at least one patent at a non-public firm within one year after an IPO. If an IPO

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[46] The 884 firms filed patent applications one year before IPO, and those patents were granted eventually.
[47] In my sample, totally there are 7,060 patent inventors and 779 patent inventors left the IPO firm within one year after an IPO and joined non-public firms.
[48] Cyclers also have more patents and citations than stayers. Stayers are defined as the inventors that were in the IPO firm one year before an IPO and still in the firm one year after an IPO.

firm has at least one cycler, the firm is treated as a firm with cyclers. Among the 884 IPOs, 318 firms have cyclers and 566 firms have no cyclers. Investigating the effects of talent cycling on a firm's long-run performance, I first use buy-and-hold benchmark-adjusted returns. The benchmarks are CRSP value-weighted index, CRSP equal-weighted index and a portfolio of non-IPO firms matched to IPO firms on size and market-to-book (style-matched firms). Results indicate that firms with cyclers have poor long-run performance compared to firms with no cyclers. The differences in the market-adjusted returns and style-adjusted returns are about 35% and 50%, respectively, for three years post IPO. After controlling for other factors that may impact IPO long-run performance, I still find that firms with cyclers underperform firms with no cyclers by about 33% for three years post IPO based on the market-adjusted returns and 62% based on the style-adjusted returns. Firms with higher talented cyclers perform even worse. Further, firms with cyclers have worse accounting performance and are more likely to be merged compared to firms with no cyclers.[49]

Though talent cycling is associated with IPO long-run underperformance, there is a positive side of talent cycling. Talent cycling increases the probability of an IPO in the economy. Specifically, I find that among the 318 firms with cyclers, 28 firms went public with the help of those cyclers, so the probability of an IPO with the help of cyclers is 8.81% compared to the overall probability of an IPO in the U.S., which is only 0.09%.[50] In the matched sample analysis, I match the 318 firms with cyclers with another 318 firms that have patents including public and non-public firms based on the patents' technological classification, the number of patents in the

[49] I also use an alternative statistical approach—the calendar-time factor model—that avoids the overlap problem with buy-and-hold returns (Brav, 2000) to examine the long-run returns. Using the Fama-French (1993) 3-factor model and the 3-factor model purged IPO and SEO firms (Loughran and Ritter, 2000), I still find that firms with cyclers perform worse than firms with no cyclers.

[50] The probability of an IPO in the U.S. is based on the statistics from to the Statistics of U.S. Business data on 2015. There are a total of 5,900,731 firms in the U.S. and only 5,288 public firms

firm, the number of citations received by the patents in the firm, and the number of inventors in the firm. The probability of an IPO in the matched sample is only 0.31%.[51]

If cyclers left the IPO firm because they have the expectation that the firm's future performance will be poor, then there is an endogeneity issue. To deal with the endogeneity problem, I use the Inevitable Disclosure Doctrine (IDD), a legal doctrine that significantly prevents inventor mobility, as the instrument variable defined as a dummy variable equal to one if the state adopts the IDD by the state court. After controlling for the endogeneity issue, I find that firms with cyclers underperform firms with no cyclers by about 17% for three years post IPO based on the market-adjusted returns and 40% for four years post IPO based on the style-adjusted returns.[52]

Though talent cycling is different from human capital loss as defined in Eiling (2013), I also show that after controlling for the changes in human capital measured by salary expenses or the changes in the number of employees, the results remain the same and human capital has no impact on IPO long-run performance.[53] I also show that the results are robust to different time periods, such as the bubble period and the hot market period.

My paper is closely related to Campbell, et al. (2012). They study the firm performance consequences of losing talent and find that firms with employees that move to a new start-up perform worse than firms with employees that move to an established firm. We both study the inventors that left the firm and categorize them based on which of two types of firms they go to and the effects on firm performance. However, we differ in two ways. Campbell, et al. use

[51] In the matched sample, only one firm is public firm.
[52] The other method of dealing with endogeneity issue is to employ the propensity score matching procedure. The results are quantitatively similar as the results using the IV.
[53] Talent cycling indicates the outflow of the best talent in the firm, while human capital refers to all the employees, not just the best talent.

revenues per employee to measure firm performance, while I study the stock long-run performance, accounting performance and also the survival probability. Second, I focus on explaining the effect of outflow of talent on IPO long-run underperformance, which they did not study.

This paper contributes to the literature in several ways. First, this paper is complementary to a growing body of literature that explores the explanations of IPO long-run underperformance, such as underwriter and venture capital reputation (Carter, el at., 1998; Krishnan, et al., 2011), earnings management (Teoh, at el., 1998), the quality of top management (Chemmanur and Paeglis, 2005) and acquisition activity ((Brau, et al., 2012). Second, this paper also adds to the inventor mobility literature that investigates the reasons (Marx, Strumsky, and Fleming, 2009; Palomeras and Melero, 2010) and consequences (Topel and Ward, 1992; Almeida and Kogut, 1999; Campbell, et al., 2012) of inventor mobility.

II. SAMPLE CONSTRUCTION AND VARIABLE MEASUREMENTS

The data is collected from several different databases. I identify IPO firms and their characteristics from Securities Data Company (SDC) database. Firm financial information is obtained from Compustat. Stock returns are obtained from the daily returns file of Center for Research in Security Prices (CRSP). Patent inventor information for identifying talent cycling comes from the Harvard Business School (HBS) patenting database constructed by Li, Lai, D'Amour, Doolin, Sun, Torvik, Amy and Fleming (2014).

I follow Brau, Couch and Sutton (2012) to exclude firms in the financial industry (Standard Industrial Classification (SIC) codes between 6000 and 6999), firms with offer price under $5 per share, foreign issuers, real estate investment trusts (REITs), unit offers, closed-end funds, and limited partnerships. I also restrict the IPO firms in my sample to those that have innovation, which means that the IPO firms have at least one patent application one year before an IPO.[54] Since the HBS patenting database ends in 2010, and there were only 21 and 41 IPOs in the financial crisis years of 2008 and 2009, respectively, and most importantly, those IPOs did not have any patent application one year before an IPO, my sample includes U.S. IPOs completed between 1985 and 2007.[55] In total, there are 3,833 IPO firms in the 1985-2007 period,

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[54] My results remain the same if I restrict the IPO firms in my sample to have at least one patent application two years before an IPO. And if I restrict the IPO firms in my sample to have at least one patent application three years before an IPO, our main results remain the same but the significance is decreased. The results are available upon request.

[55] The sample starts from 1985 due to the limited coverage in the SDC for the variable, the first and second day trading price, which I used to compute for initial return, the control variable used in the regression analysis.

including 884 firms with innovation. My results are based on the 884 innovative firms from 1985 to 2007.

VARIABLE MEASUREMENTS

The HBS patenting database provides unique identifiers (variable: Invnum_N) for each patent's inventors. I follow Bernstein (2015) to define an inventor as a leaver if the inventor has at least one patent at an IPO firm one year before an IPO and at least one patent in a different firm one year after an IPO.[56] I choose a one year period because the average (median) period between two patents applied by inventors in my sample is 11.42 (5.00) months.[57] Further, I distinguish leavers into cyclers and non-cyclers based on the firm type that they go to one year after an IPO. A cycler is defined as an inventor with at least one patent at an IPO firm and at least one patent at a non-public firm one year after an IPO. A non-cycler is defined as an inventor with at least one patent at an IPO firm and at least one patent at a public firm one year after the IPO. The inventors that were in the IPO firm one year before the IPO and still in the IPO firm one year after the IPO are defined as stayers. Therefore, the inventors that the IPO firm has one year before an IPO are divided into three categories: cyclers, non-cyclers and stayers.

I define a firm with leavers as a firm that has at least one cycler or non-cycler, and a firm with cyclers as a firm that has one or more than one cycler.[58] I also use two continuous variables to measure the cyclers in the IPO firm: the number of cyclers defined as the simple count of

[56] The time frame that Bernstein uses is three years before and five years after the IPO filing. In Bernstein (2015) footnote 20, he verifies that "all inventor relocations are not mistakenly associated with acquisitions and name changes." Hoisl (2007) also uses the similar way to define an inventor as a leaver.
[57] The average (median) period between two patents invented by leavers in my sample is 9.09 (4.00) months. The average (median) period between two patents invented by non-leavers in my sample is 11.85 (6.00) months. Using difference time periods, the results either remain the same or the significance level declined a little. The results are available upon request.
[58] Only 27 firms have inventors that are all cyclers, and 48 firms have more than 50% of cyclers over all the inventors.

number of cyclers in the firm, and the percentage of cyclers defined as the number of cyclers to the total number of inventors in the firm. Further, I measure the quality of cyclers using patents and citations. Cyclers' patents are defined as the total number of patents made by cyclers in an IPO firm, and cycler's citations are defined as the total citations received by a cycler's patents in an IPO firm.

Table 1 provides the frequency distribution by IPO year and industry in firm level. In Panel A, the sample includes a total of 3,833 IPO firms. Only 884 (23.1%) IPO firms have innovation one year before the IPO year.[59] Among the 884 firms with innovation one year before IPO year, 383 (43.3%) IPO firms have leavers, suggesting that in almost half of firms that have talent, the talent left one year after an IPO. Of the 383 firms with leavers, 318 firms (83%) have cyclers, suggesting that in most firms that have leavers, the leavers left their original IPO firms and went to non-public firms.

The results are consistent with the phenomenon of talent cycling. Panel B shows the frequency distribution by the Fama and French 12 industries at the firm level.[60] Except for the low innovative industries including energy, utilities and financial industries, all the other industries have firms with cyclers. Table 2 presents the frequency distribution by year in inventor level. The 884 firms with innovation one year before the IPO have a total of 7,060 inventors. Among the 7,060 inventors, 1,082 (15.3%) inventors left the IPO firms within one year after an IPO, and 779 out of 1,082 (72.0%) leavers are cyclers. The results suggest that IPO firms lose more than 10% of their talent within one year after an IPO.

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[59] I define a firm with innovation if the firm has at least one patent application in the IPO year. According to Hall, Jaffe and Trajtenberg (2001), the relevant time placer for patents should be the application date, and on average, there is a 2-year lag between patent's application date and grant date.

[60] The Fama and French indsutries are defined in Fama's website. http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html#Research

Next, I examine whether the talent that left their IPO firms within one year after an IPO are the best talent. Table 3 presents the results. Panel A shows cyclers' statistics at the firm level. I find that 36% of firms have cyclers and on average, a firm has 0.88 cycler and the percentage of cyclers calculated as the number of cyclers over the total number of inventors in a firm is 11%. The average number of patents (citations) the cyclers have in the IPO firms one year before an IPO is 1.22 (47.36), and the number of patents (citations) per cycler is 0.53 (19.66). In Panel B, I compare a firm's cyclers and newcomers defined as the number of new inventors who join the firm one year after an IPO. I find that on average, firms have more inventors joining the firm than leaving the firm one year after an IPO. The number of cyclers is significantly less than the number of newcomers, and the percentage of cyclers is 13% less than the percentage of newcomers. However, the quality of newcomers measured by patents and citations is significantly lower than that of the cyclers. On average, a firm's cyclers have more patents and citations than newcomers, and the number of patents (citations) per cycler is 1.24 (50.82) more than the number of patents (citations) per newcomer.[61] The results indicate that IPO firms' newly hired inventors are less talented than their cyclers.

In Panel C, I compare the difference between cyclers and stayers in the same IPO firm. I find that although cyclers have fewer patents than stayers, they have more citations. When I calculate the number of patents or citations per inventor, I find that in the same IPO firm, on average, cyclers have more patents and citations than stayers, suggesting that inventors that chose to leave the IPO firm within one year after an IPO are better inventors. Further, I compare cyclers with non-cyclers in inventor level. In Panel D, I compare cyclers and non-cyclers in the same IPO firm. In other words, the sample only restricts to firms that have both cyclers and non-

[61] Newcomer's patents are calculated as the number of patents the newcomer has in the firm one year after an IPO.

cyclers. If a patent is made by at least one cycler (non-cycler), I count this patent as a cycler's (non-cycler's) patent.[62] I find that in the same firm, cyclers' patents and citations are significantly more than non-cyclers', suggesting that cyclers are better than non-cyclers in the same firm. In Panel E, I find that on average, cyclers have significantly more patents and citations than non-cyclers, suggesting that cyclers are better inventors. Overall, the results show that more than one third of firms have cyclers and those cyclers are the best talent in the firm, consistent with the phenomenon of talent cycling.

Four performance measurements are constructed to measure IPO long-run performance: buy-and-hold abnormal return, match-adjusted return on assets (ROA), market-to-book ratio and the listing survival.

Following Ritter and Welch (2002) and Brau, Couch and Sutton (2012), I construct the buy-and-hold abnormal return for IPO firms from the IPO date to up to four years after an IPO as the monthly stock raw return subtracting the monthly benchmark return for the corresponding month. A successive 21-trading-day period is considered to be one month, and the first day return of an IPO firm is not used to calculate the first month return. The buy-and-hold abnormal stock return is calculated in equation (1).

$$AR_{0,3}^{i} = \prod_{t=1}^{36}(1 + r_t^i) - \prod_{t=1}^{36}(1 + r_t^b), \tag{1}$$

where $AR_{0,3}^{i}$ is the buy-and-hold benchmark-adjusted return for firm i for months 1-36 after going public, r_t^i is the stock raw return for IPO firm i in month t after going public, and r_t^b is the benchmark return in month t. I also calculate the buy-and-hold benchmark-adjusted return of

[62] I also define cycler's and non-cycler's patent in another way. If a patent made only by cycler (non-cycler), I count this patent as cycler's (non-cycler's) patent. The results remain the same and are available upon request.

months 1-12 ($AR^i_{0,1}$), 1-24 ($AR^i_{0,2}$), 1-48 ($AR^i_{0,4}$), 12-24 ($AR^i_{1,2}$), 12-36 ($AR^i_{1,3}$), and 12-48 ($AR^i_{1,4}$) after firm i IPO. If IPOs are delisted before their 3-year anniversary, I follow Ritter (1991) and Loughran and Ritter (1995) to truncate their abnormal return at the delisting date and use the truncated abnormal return for all longer horizon returns for those IPOs. I also calculate the cumulative abnormal returns in equation (2).

$$CAR^i_{0,n} = \sum_{t=0}^{n} AR^i_t, \tag{2}$$

where $CAR^i_{0,n}$ is the cumulative benchmark-adjusted return from IPO year to month n, and AR^i_t is the benchmark-adjusted return for firm i in month t.

The buy-and-hold stock abnormal return is calculated using three benchmarks: CRSP value-weighted index, CRSP equal-weighted index and a portfolio of non-IPO firms matched to IPO firms on size and market-to-book (style-matched firms). I follow Lyon, Barber and Tsai (1999) and Ritter and Welch (2002) to do the style-matching procedure. First, I require the matching non-IPO firms to be listed in CRSP for at least five years and not to have issued equity within 5 years. Second, I identify a set of non-IPO firms with market capitalization ±30% of the IPO firms. Third, from the set of non-IPO firms I choose the firm that has the closest market-to-book ratio as the matching firm of the IPO firm. If the matching firm is delisted prior to the return estimation ending period, I splice in the next closest market-to-book matching firm at that firm's delisted date.

The second IPO long-run performance measure is the match-adjusted ROA defined as net income divided by total assets, reflecting the firm accounting performance. I follow Krishnan, Ivanov, Masulis and Singh (2011) to do the industry match-adjustment process, and this method is also supported by Barber and Lyon (1996). Each IPO firm is matched to a sample of non-IPO firms in three years before and after the IPO date based on the IPO firm's 4-digit Standard Industrial Classification (SIC) code. If the matched sample has fewer than five firms, the IPO firm is matched to a sample of non-IPO firms based on the IPO firm's 3-digit (or 2-digit) SIC code. Then, I calculate the sample of matched firms' median ROA. The match-adjusted ROA for the IPO firm is calculated as its ROA minus the matched firms' median ROA.

The third IPO long-run performance measure is the market-to-book (M/B) ratio measured at the end of the 12th quarter after the IPO. If an IPO firm is delisted before the 12th quarter, ROA and M/B are measured at the end of the maximum quarter for which data are available in Compustat after the IPO. I also follow Krishnan, et al (2011) to winsorize the ROA and M/B at 1% and 99% levels.[63]

The fourth IPO long-run performance measure is listing survival defined as a dummy variable equal to one if the firm remains in the CRSP database for three years after IPO, and zero otherwise. The delisting reasons include financial distress, such as bankruptcy, liquidation, and going private, and exclude mergers. I investigate whether firms whose talent has left are more likely to have financial distress problems. The listing survival captures an IPO firm's financial strength. In my sample, there are a total of 988 firms delisted three years after the IPO including 365 firms delisted due to financial distress and 623 firms delisted due to mergers.[64] Since about two thirds of firms are delisted due to mergers, I further examine the effect of talent cycling on a firm's merger activities by creating a variable, merger, defined as a dummy variable equal to one

[63] The results remain the same as the results without winsorize.
[64] Among the 623 firms delisted due to mergers, only 41 firms have cyclers. Among 885 IPO firms that have innovation one year before an IPO, there are a total of 115 firms delisted three years after IPO including 20 firms delisted due to financial distress and 95 firms delisted due to mergers

if the firm is delisted due to merges, and zero otherwise. I investigate whether innovative firms whose talent has left within one year after an IPO are more likely to be acquired by other firms.

III. IPO Underperformance

Table 4 presents the buy-and-hold abnormal return for up to 3 years. Panel A shows the abnormal returns for the full sample including 3,833 IPOs from 1985 to 2007. The average market-adjusted returns are significantly negative for the holding periods for up to three years post IPO. Specifically, the mean market-value-weighted-adjusted return for three years after an IPO is -16.20%, which is comparable to the market-adjusted return in prior literature, such as Loughran and Ritter (1995), Ritter and Welch (2002) and Brau, Couch and Sutton (2012). The average style-adjusted return is only -2.51% consistent with Brav and Gompers (1997) that IPO long-run performance is sensitive to the benchmarks choice and smaller if using size and market-to-book matched sample. In Panel B, I compare the buy-and-hold abnormal returns between firms with innovation and firms with no innovation. I find that firms with innovation perform better than firms with no innovation for up to three years after an IPO. For example, the mean market-value-weighted-adjusted return for three years post IPO is -5.64% for firms with innovation and -19.37% for firms with no innovation and the difference test is significant at 5% level.

Panel C presents the results of abnormal returns for firms with no leavers in column (1), firms with cyclers in column (2) and firms with non-cyclers in column (3). Comparing the abnormal returns between firms with no leavers and firms with cyclers, I find that firms with cyclers significantly underperform firms with no leavers for three years post IPO, and the difference in the style-adjusted return is -46.69% with 5% level significance. The results suggest that firms' loss of their best talent after an IPO is a reason for IPO long-run underperformance. Next, I compare the abnormal returns between firms with cyclers and firms with non-cyclers and find that firms with non-cyclers perform better than firms with cyclers two and three years after an IPO, suggesting that inventors that went to non-public firms are better talent than inventors that went to public firms within one year after an IPO and a reason for underperformance is firm's loss of their best talent. Further, I compare firms with stayers with firms with non-cyclers. I find that there is no difference in the buy-and-hold abnormal returns for up to three years. The results are consistent with my argument that non-cyclers that left IPO firms and went to public firms within one year after an IPO are not the best talent in the IPO firms. Therefore, IPO firms with non-cyclers do not have poor long-run performance. In the following analysis, I combine firms with stayers with firms with non-cyclers into a category of firms with no cyclers. Panel D presents the results of comparing firms with cyclers and firms with no cyclers. Again, I find that firms with cyclers have poor long-run performance compared to firms with no cyclers, and the differences in abnormal returns are larger and more significant. The differences between firms with cyclers and firms with no cyclers in market-adjusted return and the style-adjusted return are around 35% and 50%, respectively, for three years post IPO.

Next, I examine the cumulative buy-and-hold benchmark-adjusted returns for IPO firms from 1985 to 2007 with monthly rebalancing for up to 36 months after an IPO. Figure 1 plots the results for the full sample, 3,833 IPO firms. I find that IPO firms underperform the CRSP value-weighted index by 17.09%, the CRSP equal-weighted index by 45.05%, and the style-matched firms by 13.53% over three years. The results are comparable to Ritter (1991) and Teoh, Welch and Wong (1998) and consistent with Ritter that the CARs are sensitive to the choice of benchmarks. In Figures 2 to 4, I compare firms with innovation and firms with no innovation for benchmark-adjusted returns and find that firms with innovation perform better than firms with no innovation. The results are consistent with prior literature that innovation has positive impact on stock return (Patel and Ward, 2011; Hirshleifer, Hsu and Li, 2013). In Figures 5 to 7, I compare firms with cyclers and firms with no cyclers (plus the overall average—firms with innovation) for value-weighted-adjusted returns, equal-weighted-adjusted returns and style-adjusted returns, respectively. I find that firms with cyclers outperform firms with no cyclers and the differences become greater over time, suggesting that losing cyclers, the best talent in the firms, the IPO firms perform worse and worse over time.

In this section, I employ a multivariate regression analysis controlling for other factors that may affect IPO long-run performance. I also use calendar-time factor model regressions to test IPO long-run performance of firms with cyclers and firms with no cyclers.

3.2.a Cross-Sectional Regression Analysis

I control for other factors that may affect IPO long-run performance. Prior studies document that lead underwriter reputation and venture capital (VC) backing significantly affect IPO firms' long-run performance (Brav and Gompers, 1997; Carter, et al. 1998). I measure VC backing (variable: VC)) as a dummy variable equal to one if the firm is VC-backed, and zero otherwise. I obtain the rankings of lead underwriter (variable: UW rank) from Loughran and Ritter (2004).[65] Following Krishnan, et al. (2011), I also control for IPO firm quality by including the IPO first day return (variable: Initial return) defined as the closing price one day after the offering date divided by offering price minus one[66], Tobin's Q (variable: Ln (Tobin's Q)) defined as the natural logarithm of market value of assets over the book value of assets, and

[65] The data is from Ritter's website. https://site.warrington.ufl.edu/ritter/ipo-data/
[66] If closing price one day after the offering date is missing, I use closing price two days after the offering date.

market capitalization (variable: Ln(Market cap)) defined as the natural logarithm of offer price multiplied by the total number of post-IPO shares. IPO literature (Krishnan et al., 2011; Brau, et al., 2012) controls for firm age when studying IPO long-run performance. Firm age at the IPO (variable: Ln(1+age)) is from Loughran and Ritter (2004) measured as the natural logarithm of one plus the number of years from founding year to IPO year. Since I study the effect of outflow of talent after IPO year on firms' long-run performance, the newly joined inventors after the IPO might confound the results. Therefore, I also control for the ratio of the number of newcomers to the total number of inventors in the firm one year (variable: Newcomer01_perc), two years (variable: Newcomer02_perc), three years (variable: Newcomer03_perc) and four years (variable: Newcomer04_perc) after an IPO year depending on the use of stock return periods.

Table 5 presents the summary statistics for the control variables. I find that in my sample, 66% of firms are backed by VC and on average, firm's lead underwriter has a 7.56 ranking score on a 1-9 scale. Since my sample only includes firms with innovation, those firms are very young with an average age of 2.17 years and have a large initial day return of 31.41%. I also find that on average, 42% of inventors are newcomers one year after an IPO. Comparing firms with cyclers and firms with no cyclers, I find that firms with cyclers are younger and bigger in size (measured by market capitalization), and have higher initial return, greater growth opportunity (measured by Tobin's Q), better underwriter reputation and more firms backed by VC.

Next, I apply the following multivariate cross-sectional regression to investigate the effect of talent cycling on buy-and-hold benchmark-adjusted returns.

$$AR_{0,n}^{i} = \alpha_1 + \beta_1 Talent\ cycling_i + \beta_2 VC_i + \beta_3 \text{Ln}(1 + \text{age})_i + \beta_4 \text{Initial return}_i + \beta_5 \text{Ln(Market cap)}_i + \beta_6 \text{Ln (Tobin's Q)}_i + \beta_7 \text{UW rank}_i + \beta_8 \text{Newcomers}_i + \gamma_k + \delta_t + \varepsilon_{1i}, \quad (3)$$

where $AR_{0,n}^{i}$ is the buy-and-hold benchmark-adjusted return for firm i from IPO year to nth years after an IPO, and $Talent\ cycling_i$ is measured in five ways, (1) *cyclers* defined as a dummy variable equal to one if the firm has at least one cycler and zero otherwise, (2) *number of cyclers* defined as the quartile rank of the number of cyclers in a firm, (3) *percentage of cyclers* defined as the quartile rank of the ratio of the number of cyclers to the total number of inventors in a firm, (4) *cyclers' patent* defined as the number of patents made by cyclers, and (5) *cyclers' citation* defined as the number of citations received by cyclers' patents. I also control for industry fixed effects (γ_k) and year fixed effects (δ_t). I expect β_1 to be negatively significant, suggesting that talent cycling negatively impacts an IPO firm's long-run performance.

Table 6 presents the results of the effects of talent cycling on IPO long-run performance. In Panel A, I find that after controlling for other factors that might affect IPO long-run performance, firms with cyclers underperform firms with no cyclers. Specifically, firms with cyclers lower the abnormal return by about 30% for three years post IPO based on the market-adjusted return and 55.4% for four years post IPO based on the style-adjusted return. In Panels B and C, I use continuous variables, *number of cyclers* and *percentage of cyclers* ranked by quartile, to measure talent cycling and find that firms with more cyclers have worse IPO long-run performance up to four years after an IPO. In Panels D and E, I use *cyclers' patents* and *cycler's* citations to measure cyclers' quality and find that firms that have higher quality cyclers who left within one year after an IPO perform even worse. Next, I examine the buy-and-hold benchmark-adjusted return excluding the first year and calculate the buy-and-hold benchmark-adjusted return of months 12-24 ($AR_{1,2}$), 12-36 ($AR_{1,3}$) and 12-48 ($AR_{1,4}$) after an IPO. Panel F presents the results. I find that firms with cyclers underperform firms with no cyclers for the period of 12-36 months after an IPO when the return's benchmark is a portfolio of firms matched by size and book-to-market. However, firms with cyclers do not underperform firms with no cyclers for the period of 12-24 and 12-48 months after an IPO, suggesting that most of the underperformance comes from the first year after an IPO. The results are consistent with talent cycling since I measure an inventor as a cycler if the inventor has at least one patent at a non-public firm within one year after an IPO. Therefore, firms that lose their best talent within one year after an IPO perform worse than the firms that do not suffer talent outflow one year after an IPO. Further, in Panel G, I examine the effect of talent cycling on firm's accounting performance, survival and whether they are more likely to be merged. I find that firms with more cyclers have worse accounting performance measured by ROA and are more likely to be merged.

Examining the control variables, I find that the percentage of newcomers is positively related to the buy-and-hold benchmark-adjusted returns, suggesting that the talent is important to the innovative firms. In the style-adjusted model, VC backing is positively and significantly related to the buy-and-hold benchmark-adjusted returns one year after an IPO, consistent with Brav and Gompers (1997). I also find that firms with lower initial returns, bigger size and greater growth opportunities are associated with better long-run performance.

CALENDAR-TIME FACTOR MODEL REGRESSION

Since Brav (2000) points out the overlap problem with buy-and-hold returns, I use an alternative statistical approach that avoids this problem to examine the long-run returns, the calendar-time factor model regressions. First, I use the Fama-French (1993) 3-factor model and estimate the model as follows.

$$R_{pt} - r_{ft} = a + b\left(R_{mt} - r_{ft}\right) + sSMB_t + hHML_t + e_t, \qquad (4)$$

where R_{pt} is the return for an equal-weighted calendar-time portfolio of IPOs in month t, r_{ft} is the return on the three-month T-bill in month t, $R_{mt}$is the return on the value-weighted market index in month t, $\left(R_{mt} - r_{ft}\right)$ is the market risk premium MRP, SMB_t is the return on a value-weighted portfolio of small firms minus the return on a value-weighted portfolio of large firms in month t, and HML_t is the return on a value-weighted portfolio of high book-to-market stocks minus the return on a value-weighted portfolio of high book-to-market stocks in month t. The intercept (a) measures the abnormal performance.

In Table 7, I report the results for the full sample in column (1), firms with no innovation in column (2), firms with innovation in column (3), firms with no cyclers in column (4) and firms with cyclers in column (5). I also calculate the returns for the portfolio of IPO firms for the period of 0-6 months after an IPO in Panel A, 0-12 months after an IPO in Panel B, 0-24 months after an IPO in Panel C, 0-36 months after an IPO in Panel D and 0-48 months after an IPO in Panel E. Comparing firms with innovation and firms with no innovation, I find that IPO firms with innovation have significantly positive abnormal returns for the period of 0-6 months, 0-36 months and 0-48 months after an IPO, while IPO firms with no innovation have no abnormal returns. For example, the intercept term for firms with innovation during the prior 36 (48) months is 0.593% (0.536%) with a t-statistic of 2.10 (2.14). The results suggest that firms with innovation have a positive abnormal return, consistent with Patel and Ward (2011) and Hirshleifer, et al. (2013). Comparing firms with cyclers and firms with no cyclers, I find that IPO firms with cyclers underperform IPO firms with no cyclers. Specifically, I find that firms with cyclers have no abnormal returns, while firms with no cyclers have significant positive abnormal returns for the period of 0-6 months (1.228%), 0-36 months (0.693%) and 0-48 months (0.575%) after an IPO. The results indicate that firms with cyclers have worse long-run performance compared to firms with no cyclers, suggesting that talent cycling explains IPO long-run underperformance.

Brav, Geczy and Gompers (2000) argue that the findings of the underperformance of IPO firms is the result of the misspecification of the three-factor model for predicting returns on small growth firms. Loughran and Ritter (2000) address this concern by using the Fama-French three-factor regression after purging the factors of new issues and find a greater underperformance. Next, I reexamine the equation (4) by using the Fama-French three-factor regression after purging the factors of new issues where SMB_t is the return on a value-weighted portfolio of small firms minus the return on a value-weighted portfolio of large firms in month t purged of IPO and SEO firms, and HML_t is the return on a value-weighted portfolio of high book-to-market stocks minus the return on a value-weighted portfolio of high book-to-market stocks in month t purged of IPO and SEO firms. The data for the three-factor model purged of IPO and SEO firms is from Ritter's website for the period of 1973 to 2003.[67]

Table 8 presents the results for the calendar-time factor model regressions using the Fama-French 3-factor model purged of IPO and SEO firms from 1985 to 2003. The results in Table 8 are basically the same as the results in Table 7. I also find that in the full sample, IPO firms have a significant average monthly abnormal return of -0472% in Panel B, which is

[67] https://site.warrington.ufl.edu/ritter/ipo-data/

consistent with Loughran and Ritter (2002) that IPO firm underperform using the Fama-French 3-factor model purged of IPO and SEO firms.

IV. THE ECONOMIC BENEFITS OF TALENT CYCLING IN IPO

Although talent cycling is one of the reasons of IPO long-run underperformance, there are some economic benefits of talent cycling in IPO. In my sample, there are 318 firms with cyclers and a total of 779 cyclers. Those cyclers left their original IPO firms and went to non-public firms. And then, there are 28 firms that went public with the help of those cyclers, so the probability of an IPO with the help of cyclers is 8.81%.[68] However, according to the Statistics of U.S. Business data on 2015 for U.S., there are a total of 5,900,731 firms in the U.S. and only 5,288 public firms, so the probability of an IPO in the U.S. is only 0.09%.[69]

In order to further examine the economic benefits of talent cycling, I conduct a match sample procedure. The sample is from the HBS patenting database including all the public firms and non-public firms with patents. I first delete the 318 firms with cyclers in the sample. Then, I match the 318 firms with cyclers with another 318 firms in that sample based on the patents' technological classification, the number of patents in the firm, the number of citations received by the patents in the firm, and the number of inventors in the firm. Among the matched 318 firms, only one firm is a public firm, so the probability of an IPO without the help of cyclers is only 0.31%.[70] Therefore, talent cycling in IPO helps more firms to go public and increases the probability of an IPO in the U.S.

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[68] 28/318=8.81%

[69] 5,288/5,900,731=0.09%. The Statistics of U.S. Business data is obtained from https://www.census.gov/data/tables/2015/econ/susb/2015-susb-annual.html

[70] 1/318=0.31%

V. ENDOGENEITY ISSUE

If the cyclers choosing to leave after an IPO is because they have information about the future performance of the IPO firm and an expectation that the firm's performance is decreasing, there is a concern that the underperformance of firms with cyclers could not be due to the leave of cyclers, and β_1 in equation (3) is biased due to endogeneity. I control for the endogeneity issue in two ways: (1) find an instrument variable and use two-stage least square (2SLS) model, and (2) use propensity score matching method.

2SLS RESULTS

The 2SLS model requires a selection of instrument variables (IV). Successful IV candidates must satisfy two criteria. The first criterion is that the instrument does not correlate with the error term in equation (3). The second is that the instrument affects firm long-run performance only through talent cycling. Therefore, I use the Inevitable Disclosure Doctrine (IDD) as the instrument variable defined as a dummy variable equal to one if the state adopts the IDD by the state court.[71] The IDD is a legal doctrine in trade secret law that prevents a firm's current or former employee from working for a rival firm if the firm demonstrates that the employee would "inevitably" disclose the firm's trade secrets to the rival firm. Since Klasa, Ortiz-Molina, Serfling and Srinivasan (2017) find that the adoption of IDD in states significantly

[71] Klasa, et al. (2017) Table 1 shows the 21 precedent-setting cases in which state courts adopt the IDD.

reduces the mobility of talent to rival firms, and Hansen's J-test of overidentifying restrictions is not significant, the IDD is a valid instrument variable.

I estimate the following first-stage regression:

$$
\begin{aligned}
Talent\ cycling_i &= \alpha_1 + \beta_1 VC_i + \beta_2 \text{Ln}(1+\text{age})_i + \beta_3 \text{Initial return}_i + \beta_4 \text{Ln}(\text{Market cap})_i \\
&+ \beta_5 \text{Ln (Tobin's Q)}_i + \beta_6 \text{UW rank}_i + \beta_7 \text{Newcomers}_i + \beta_8 \text{IDD}_i + \gamma_k + \delta_t \\
&+ \theta_t + \varepsilon_{1i}, \qquad (5)
\end{aligned}
$$

where IDD_i is the instrument variable for $Talent\ cycling_i$. I also control for industry fixed effects (γ_k), year fixed effects (δ_t) and state fixed effects (θ_t). The second-stage equation estimates the impact of talent cycling on firm long-run stock performance:

$$
\begin{aligned}
AR_{0,n}^{i} &= \alpha_1 + \beta_1 \widehat{Talent\ cycling_i} + \beta_2 VC_i + \beta_3 \text{Ln}(1+\text{age})_i + \beta_4 \text{Initial return}_i \\
&+ \beta_5 \text{Ln}(\text{Market cap})_i + \beta_6 \text{Ln (Tobin's Q)}_i + \beta_7 \text{UW rank}_i + \gamma_k + \delta_t + \theta_t \\
&+ \varepsilon_{1i}, \quad (6)
\end{aligned}
$$

where $\widehat{Talent\ cycling_i}$ is the predicted value from the regression in equation (5).

Table 9 presents the results of the effect of talent cycling on IPO long-run performance using 2SLS model. In Panel A, I calculate the buy-and-hold benchmark-adjusted returns including the first year after an IPO up to the fourth year after an IPO and find that firms with cyclers underperform firms with no cyclers. Specifically, firms with cyclers have lower abnormal returns by about 16% over years 1-3 after going public based on the market-adjusted return and about 40% over years 1-4 after going public based on the style-adjusted return. In Panel B, I calculate the buy-and-hold benchmark-adjusted returns excluding the first year after an IPO and find that firms with cyclers underperform firms with no cyclers by about 12% over years 2-3 after going public based on market-adjusted return and about 30% over years 2-4 after going public based on style-adjusted return. Controlling the endogeneity issue, I find that the results are consistent with the results of using OLS regressions in general, suggesting that the outflow of the best talent is the reason for IPO long-run underperformance.

Examining the control variables, I find that IPO firms with lower initial returns, high potential of growth and large size are associated with greater long-run stock returns after an IPO. I also find that IPO firms backed by VC tend to have better long-run performance after an IPO, consistent with Brav and Gompers (1997). The percentage of newcomers after an IPO is positively related to the buy-and-hold benchmark-adjusted returns, suggesting that the talent is very important to the innovative firms.

PROPENSITY SCORE MATCHED SAMPLES

The second way that I deal with the endogeneity problem is to employ a propensity score matching procedure (Rosenbaum and Rubin, 1983). Using this methodology, I can construct a control sample of firms with no cyclers that exhibit no observable differences in firm and inventor characteristics compared to firms with cyclers. Therefore, if the two samples' long-run performance is different, the only reason can be due to the fact that cyclers left the firm.

The first step of implementing this methodology is to calculate the probability (propensity score) from the logit regression for all the firms in the sample using all the control variables in equation (3). Then, I construct the matched sample by choosing the firms that have no cyclers with propensity scores closest to each firm that has cyclers. Next, I run OLS regressions including firms with no cyclers (the matched sample) and firms with cyclers controlling for firm characteristics, year fixed effects and firm fixed effects. The results are presented in Table 10. I find that firms with cyclers perform worse than firms with no cyclers by about 35% over years1-3 after going public based on market-adjusted return and about 60% over years 1-4 after going public based on style-adjusted return. The results are consistent with the results in the previous OLS regressions, suggesting that IPO long-run underperformance can be explained by talent cycling in IPO.

VI. ROBUSTNESS

Since I use the number of inventors who left the firm within one year after an IPO to measure the number of cyclers in a firm, I may just capture the number of employees who left the firm within one year after an IPO. Further, since cyclers are the best talent in the firm, the outflow of cyclers has a negative impact on IPO long-run performance. However, the outflow of normal employees should not have a negative impact on IPO long-run performance. Therefore, I add one variable, the number of employees, into equation (3). The number of employees is defined as the difference between the number of employees one year after an IPO and one year before an IPO over total assets. Table 11 Panel A presents the results. I find that the number of employees is positively related with IPO long-run performance only for the first year after an IPO, and *cyclers* is still negatively related to IPO long-run performance up to three years after an IPO. The results suggest that increasing the number of employees will not affect firm long-run performance since increasing the number of employees could be due to the expansion of operations or the decrease in productivity. However, the outflow of cyclers has a negative impact on IPO long-run performance since cyclers are the best talent in the company.

Eiling (2013) studies human capital and cross-section of expected stock returns and finds that human capital measured by salary expenses affects the cross-sectional of expected stock returns. In order to show that *cyclers* is a better proxy to capture the best talent than human capital measured by salary expenses, I add one variable, salary expenses, into equation (3). The salary expense is defined as the quartile rank of the differences between the salary expenses one year after an IPO and one year before an IPO.[72] Panel B in Table 11 presents the results. I find that adding salary expenses into equation (3) does not change the results. Firms with cyclers have worse long-run performance than firms with no cyclers, but salary expense has no relation with long-run performance.

One concern of examining IPO long-run performance is the effect of the stock market internet bubble in 1999 and 2000 (Brau, Couch and Sutton, 2012). Therefore, I reexamine equation (3) by excluding firms that went public during the bubble years, 1999 and 2000. Table 11 Panel C presents the results. I find that the results generally remain the same as the previous findings for the full sample. Without the bubble years, firms with cyclers perform even worse than firms with no cyclers by about 42% over years1-3 after going public based on market-adjusted return and about 77% over years 1-4 after going public based on style-adjusted return.

Another concern of this paper is that there might be more inventors who left the firm within one year after an IPO during hot IPO market because of more IPOs during hot market. Therefore, I reexamine equation (3) by adding one variable, hot market, defined as a dummy variable equal to one if the number of IPOs in a year is greater than the median number of IPOs in the sample by year. Table 11 Panel D presents the results. I find that the results are the same as the previous results and hot market is not significant.

[72] The missing value of salary expenses is set to zero.

VII. CONCLUSION

In this paper, I study talent cycling in IPOs and examine the effect of talent cycling on IPO long-run performance and economic benefits of talent cycling. Talent cycling in IPOs refers to the job seeking behavior in high-tech firms where talented patent inventors leave once an IPO is successful and then pursue another job at a private firm. I define an inventor as a cycler if the inventor left the firm within one year of IPO and then went to a non-public firm. If a firm has at least one cycler, I define the firm as a firm with cyclers. In my sample, 36% of firms have cyclers. Comparing cyclers, non-cyclers and newcomers in the IPO firms, I find that cyclers are the best talent. Therefore, the outflow of the best talent in the IPO firms would negatively impact their long-run performance. Specifically, I find that firms with cyclers underperform firms with no cyclers in the univariate tests and the multivariate tests after controlling for other factors that may impact IPO long-run performance. I also find that firms with more cyclers perform even worse. One concern of this paper is that inventors who left the firm within one year after an IPO due to the fact that they had information and expectations about the firm’s poor future performance. To deal with the endogeneity issue, I employ 2SLS regressions and the propensity score matching method and find the results remain the same. Talent cycling also brings economic benefits to the IPO market. I find that talent cycling increases the probability of an IPO. Further, I show that talent cycling is different from human capital loss since the results are robust to the changes in the number of employees who left and the changes in human capital.

The results are also robust to the different time periods, such as the bubble periods and the hot market periods.

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APPENDIX

APPENDIX 1: Frequency Distribution by IPO Year and Industry in Firm Level

Table 1

Frequency Distribution by IPO Year and Industry in Firm Level

This table provides the frequency distribution of IPO firms by year and by industry from 1985 to 2007. The full sample includes 3,833 IPO firms, 884 firms that have innovation one year before IPO, 383 firms with leavers and 318 firms with cyclers. Leavers are defined as the inventors with at least one patent at an IPO firm one year before IPO and at least one patent in a different firm one year after IPO. Cyclers are defined as the inventors with at least one patent at an IPO firm one year before IPO and at least one patent in a non-public firm one year after IPO. The sample includes domestic IPO firms and excludes penny stock, financial firms, real estate investment trusts (REITs), unit offers, closed-end funds, and limited partnerships.

Panel A. Frequency Distribution by IPO Year in Firm Level

IPO Year	Frequency	% of Total sample	No. of firms with innovation one year before IPO	% of firms with innovation one year before IPO	No. of firms with leavers	% of firms with leavers	No. of firms with cyclers	% of firms with cyclers
1985	5	0.1%	0	0.0%	0	0.0%	0	0.0%
1986	157	4.1%	18	11.5%	5	27.8%	5	100.0%
1987	143	3.7%	19	13.3%	8	42.1%	6	75.0%
1988	54	1.4%	9	16.7%	3	33.3%	2	66.7%
1989	62	1.6%	13	21.0%	1	7.7%	1	100.0%
1990	62	1.6%	10	16.1%	3	30.0%	2	66.7%
1991	142	3.7%	41	28.9%	19	46.3%	16	84.2%
1992	218	5.7%	58	26.6%	19	32.8%	16	84.2%
1993	306	8.0%	68	22.2%	29	42.6%	23	79.3%
1994	250	6.5%	41	16.4%	15	36.6%	12	80.0%
1995	314	8.2%	70	22.3%	36	51.4%	30	83.3%
1996	445	11.6%	103	23.1%	48	46.6%	40	83.3%
1997	305	8.0%	51	16.7%	20	39.2%	17	85.0%

1998	180	4.7%	30	16.7%	11	36.7%	7	63.6%
1999	300	7.8%	78	26.0%	36	46.2%	33	91.7%
2000	252	6.6%	106	42.1%	66	62.3%	57	86.4%
2001	48	1.3%	18	37.5%	7	38.9%	6	85.7%
2002	50	1.3%	12	24.0%	8	66.7%	7	87.5%
2003	41	1.1%	10	24.4%	3	30.0%	3	100.0%
2004	125	3.3%	46	36.8%	27	58.7%	22	81.5%
2005	112	2.9%	26	23.2%	10	38.5%	5	50.0%
2006	127	3.3%	30	23.6%	4	13.3%	3	75.0%
2007	135	3.5%	27	20.0%	5	18.5%	5	100.0%
Total	3833	100.0%	884	23.1%	383	43.3%	318	83.0%

Panel B. Frequency Distribution by Fama and French 12 Industry Groups in Firm Level

Industry	Frequency	% of Total sample	No. of firms with innovation one year before IPO	% of firms with innovation one year before IPO	No. of firms with leavers	% of firms with leavers	No. of firms with cyclers	% of firms with cyclers
Consumer NonDurables	176	4.6%	23	13.1%	5	21.7%	4	80.0%
Consumer Durables	48	1.3%	13	27.1%	6	46.2%	6	100.0%
Manufacturing	282	7.4%	99	35.1%	30	30.3%	21	70.0%
Energy	117	3.1%	3	2.6%	0	0.0%	0	0.0%
Chems	52	1.4%	20	38.5%	8	40.0%	8	100.0%
Business Equipment	1,003	26.2%	332	33.1%	133	40.1%	107	80.5%
Telecom	139	3.6%	9	6.5%	5	55.6%	5	100.0%
Utilities	20	0.5%	1	5.0%	0	0.0%	0	0.0%
Shops	423	11.0%	9	2.1%	2	22.2%	2	100.0%
Health	576	15.0%	277	48.1%	165	59.6%	140	84.8%
Financial	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Other	997	26.0%	98	9.8%	29	29.6%	25	86.2%

APPENDIX 2: Frequency Distribution by Year in Inventor Level

Table 2

Frequency Distribution by Year in Inventor Level

This table provides the frequency distribution for inventors that the IPO firms have one year before IPO from 1985 to 2007. The full sample includes 7,060 inventors, 1,082 inventors that left the IPO firm one year after IPO, 779 inventors that left the IPO firms one year after IPO and went to non-public firms. Leavers are defined as the inventors with at least one patent at an IPO firm one year before IPO and at least one patent in a different firm one year after IPO. Cyclers are defined as the inventors with at least one patent at an IPO firm one year before IPO and at least one patent in a non-public firm one year after IPO. The sample includes domestic IPO firms and excludes penny stock, financial firms, real estate investment trusts (REITs), unit offers, closed-end funds, and limited partnerships.

IPO Year	No. of inventors	% of Total sample	No. of leavers	% of leavers	No. of cyclers	% of cyclers
1985	0	0.0%	0	0.0%	0	0.0%
1986	175	2.5%	15	8.6%	10	66.7%
1987	97	1.4%	20	20.6%	6	30.0%
1988	49	0.7%	3	6.1%	2	66.7%
1989	50	0.7%	2	4.0%	2	100.0%
1990	37	0.5%	3	8.1%	2	66.7%
1991	211	3.0%	25	11.8%	21	84.0%
1992	277	3.9%	35	12.6%	30	85.7%
1993	445	6.3%	66	14.8%	46	69.7%
1994	228	3.2%	50	21.9%	42	84.0%
1995	617	8.7%	82	13.3%	63	76.8%
1996	674	9.5%	118	17.5%	91	77.1%
1997	330	4.7%	67	20.3%	55	82.1%
1998	358	5.1%	47	13.1%	33	70.2%
1999	718	10.2%	139	19.4%	97	69.8%
2000	1,076	15.2%	232	21.6%	150	64.7%
2001	273	3.9%	19	7.0%	14	73.7%
2002	123	1.7%	20	16.3%	17	85.0%
2003	91	1.3%	9	9.9%	5	55.6%
2004	553	7.8%	77	13.9%	58	75.3%
2005	345	4.9%	38	11.0%	21	55.3%
2006	148	2.1%	7	4.7%	6	85.7%
2007	185	2.6%	8	4.3%	8	100.0%
Total	7060	100.0%	1082	15.3%	779	72.0%

APPENDIX 3: Cycler Characteristics

Table 3

Cycler Characteristics

This table provides cyclers' characteristics. Panel A shows the statistics for cyclers. Panel B compares cyclers with newcomers in the firm level. Panel C compares cyclers with stayers in the firm level. Panel D compares cyclers with non-cyclers in then inventor level. Panel E compares cyclers with non-cyclers in the firm level. Cyclers are defined as the inventors with at least one patent at an IPO firm one year before IPO and at least one patent in a non-public firm one year after IPO. Non-cyclers are defined as the inventors with at least one patent at an IPO firm one year before IPO and at least one patent in a public firm one year after IPO. Stayers are defined as the inventors in the IPO firm one year before IPO and still in the firm one year after IPO. Newcomers are defined as the new inventors join the firm one year after IPO. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

Panel A. Cycler statistics (firm level)

Variable	N	Mean	Median	Std. Dev.	P25	P75
Cycler (dummy)	884	0.36	0.00	0.48	0.00	1.00
Number of cyclers	884	0.88	0.00	1.90	0.00	1.00
Percentage of cyclers	884	0.11	0.00	0.22	0.00	0.13
Cycler's patent	884	1.22	0.00	3.07	0.00	1.00
Cycler's citation	884	47.36	0.00	207.59	0.00	14.00
Number of patents per cycler	884	0.53	0.00	1.05	0.00	1.00
Number of citations per cycler	884	19.66	0.00	73.84	0.00	8.05

Panel B. Comparing cyclers with newcomers (firm level)

	N	Mean	Difference Paired t-test
Number of cyclers	318	2.45	-4.72***
Number of newcomers	318	7.17	(-6.89)
Percentage of cyclers	318	0.32	-0.13***
Percentage of newcomers	318	0.45	(-5.48)
Cycler total patents	318	3.38	1.15***
Newcomer total patents	318	2.23	(3.83)
Cycler total citations	318	131.66	102.77***
Newcomer total citations	318	28.89	(5.60)
Number of patents per cycler	318	1.49	1.24***
Number of patents per newcomer	318	0.24	(16.79)
Number of citations per cycler	318	54.65	50.82***
Number of citations per newcomer	318	3.83	(7.95)

Panel C. Comparing cyclers with stayers (firm level)

	N	Mean	Difference Paired t-test
Cycler's patent	221	3.99	-1.82***
Stayer's patent	221	5.81	(-2.67)
Cycler's citation	221	156.16	47.16*
Stayer's citation	221	109.00	(1.86)
Number of patents per cycler	221	1.60	0.83***
Number of patent per stayer	221	0.74	(6.75)
Number of citations per cycler	221	57.63	40.57***
Number of citations per stayer	221	17.05	(5.10)

Panel D. Comparing cyclers with non-cyclers (firm level)

	N	Mean	Difference Paired t-test
Cycler's patent	138	4.71	2.28***
Non-cycler's patent	138	2.43	(5.22)
Cycler's citation	138	213.27	128.52***
Non-cycler's citation	138	84.75	(4.13)
Number of patents per cycler	138	1.57	0.53***
Number of patent per non-cycler	138	1.04	(4.69)
Number of citations per cycler	138	66.30	26.49***
Number of citations per non-cycler	138	39.81	(2.99)

Panel E. Comparing cyclers with non-cyclers (inventor level)

	N	Mean	Difference Paired t-test
Cycler's patent	779	5.76	2.58***
Non-cycler's patent	303	3.18	(2.924)
Cycler's citation	779	305.57	207.54**
Non-cycler's citation	303	98.04	(2.260)

APPENDIX 4: Abnormal Returns

Table 4

Abnormal Returns

Table 4 presents the buy-and-hold abnormal returns for the full sample (Panel A), firms with innovation and firms with no innovation (Panel B), frims with stayers, firms with cyclers and firms with non-cyclers (Panel C), and firms with cyclers and firms with no cyclers (Panel D). The benchmark returns are CRSP value-weighted index (marke_vw adj.), CRSP equal-weighted index (market-ew adj.) and a portfolio of non-IPO firms matched to IPO firms on size and market-to-book (size-MB adj.). A firm with innovation is defined as the firm has at least one patent application in the IPO year. A firm with leavers are defined as the firm has at least one inventor with at least one patent at the firm one year before IPO and at least one patent in a different firm one year after IPO. A firm with cyclers are defined as the firm has at least one inventors with at least one patent at the firm one year before IPO and at least one patent in a non-public firm one year after IPO. A firm with non-cyclers are defined as the firm's all the leavers are non-cyclers. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

Panel A. Abnormal returns for the full sample (n=3833)

Variable	Mean	p-Value
AR0,1 (market-vw adj.)	-4.38%	0.0013
AR0,1 (market-ew adj.)	-18.41%	<.0001
AR0,1 (size-MB adj.)	-3.99%	0.0374
AR0,2 (market-vw adj.)	-9.43%	0.0007
AR0,2 (market-ew adj.)	-43.27%	<.0001
AR0,2 (size-MB adj.)	-2.07%	0.5483
AR0,3 (market-vw adj.)	-16.20%	<.0001
AR0,3 (market-ew adj.)	-72.59%	<.0001
AR0,3 (size-MB adj.)	-2.51%	0.5511

Panel B. Abnormal returns for firms with innovation and firms with no innovation.

	Firms with innovation (n=884)		Firms with no innovation (n=2949)		Difference test
Variable	Mean	p-Value	Mean	p-Value	p-Value
AR0,1 (market-vw adj.)	-0.46%	0.8901	-5.55%	0.0001	0.0571
AR0,1 (market-ew adj.)	-16.47%	<.0001	-18.99%	<.0001	0.4359
AR0,1 (size-MB adj.)	0.39%	0.927	-5.30%	0.013	0.1052
AR0,2 (market-vw adj.)	-6.33%	0.2563	-10.36%	0.0011	0.5385
AR0,2 (market-ew adj.)	-44.86%	<.0001	-42.79%	<.0001	0.7552
AR0,2 (size-MB adj.)	3.59%	0.571	-3.77%	0.3536	0.1845
AR0,3 (market-vw adj.)	-5.64%	0.4798	-19.37%	<.0001	0.0372
AR0,3 (market-ew adj.)	-70.39%	<.0001	-73.25%	<.0001	0.7173
AR0,3 (size-MB adj.)	6.46%	0.5129	-5.20%	0.258	0.1214

Panel C. Abnormal returns for firms with stayers, firms with cyclers and firms with non-cyclers

	(1)		(2)		(3)				
	Firms with stayers (n=501)		Firms with cyclers (n=318)		Firms with non-cyclers (n=65)		(1) - (2) Difference test	(1) - (3) Difference test	(2) - (3) Difference test
Variable	Mean	p-Value	Mean	p-Value	Mean	p-Value	p-Value	p-Value	p-Value
AR0,1 (market-vw adj.)	5.87%	0.2482	-8.16%	0.0655	-11.67%	0.2175	0.0543	0.2269	0.7412
AR0,1 (market-ew adj.)	-9.00%	0.0754	-26.08%	<.0001	-27.02%	0.0053	0.0187	0.2124	0.9292
AR0,1 (size-MB adj.)	7.34%	0.2078	-10.51%	0.1445	0.02%	0.9988	0.0548	0.6611	0.5294
AR0,2 (market-vw adj.)	2.25%	0.7975	-22.05%	<.0001	4.49%	0.8213	0.0412	0.9300	0.0818
AR0,2 (market-ew adj.)	-34.52%	0.0001	-63.46%	<.0001	-33.68%	0.1064	0.0164	0.9742	0.0580
AR0,2 (size-MB adj.)	11.52%	0.222	-13.96%	0.1045	28.13%	0.1528	0.0626	0.5397	0.0445
AR0,3 (market-vw adj.)	6.50%	0.6103	-27.29%	0.0003	6.76%	0.8077	0.0479	0.9944	0.0995
AR0,3 (market-ew adj.)	-57.51%	<.0001	-93.88%	<.0001	-54.77%	0.0629	0.0363	0.9415	0.0730
AR0,3 (size-MB adj.)	21.24%	0.1355	-25.45%	0.0802	48.74%	0.1129	0.0283	0.5020	0.0341

Panel D. Abnormal returns for firms with cyclers and firms with no cyclers

	(1)		(2)		
	Firms with no cyclers (n=566)		Firms with cyclers (n=318)		(1) - (2) Difference test
Variable	Mean	p-Value	Mean	p-Value	p-Value
AR0,1 (market-vw adj.)	3.86%	0.4048	-8.16%	0.0655	0.0866
AR0,1 (market-ew adj.)	-11.07%	0.0165	-26.08%	<.0001	0.0316
AR0,1 (size-MB adj.)	6.50%	0.2222	-10.51%	0.1445	0.0566
AR0,2 (market-vw adj.)	2.51%	0.7565	-22.05%	<.0001	0.0342
AR0,2 (market-ew adj.)	-34.42%	<.0001	-63.46%	<.0001	0.0137
AR0,2 (size-MB adj.)	13.43%	0.1203	-13.96%	0.1045	0.0383
AR0,3 (market-vw adj.)	6.53%	0.5774	-27.29%	0.0003	0.0418
AR0,3 (market-ew adj.)	-57.20%	<.0001	-93.88%	<.0001	0.0302
AR0,3 (size-MB adj.)	24.40%	0.062	-25.45%	0.0802	0.0153

APPENDIX 5: Summary Statistics for Control Variables

Table 5

Summary Statistics for Control Variables

Table 5 presents the summary statistics for the control variables. Difference tests are calculated using a t-test for the difference in means. *VC* is a dummy variable equal to one if the firm is VC-backed and zero otherwise. *Ln(1+age)* is from Loughran and Ritter (2004) measured as the natural logarithm of one plus the number of years from founding year to IPO year. *Initial return* is defined as the closing price one day after the offering date divided by offering price minus one. *Ln(Market cap)* is defined as the natural logarithm of offer price multiplying the total number of post-IPO shares. *Ln (Tobin's Q)* is defined as the natural logarithm of market value of assets over the book value of assets. *UW rank* is the underwriter ranking from Loughran and Ritter (2004) on a 1-9 scale. *Newcomer01_perc* is the ratio of the number of newcomers to the total number of inventors in the firm one year after IPO.

	Full Sample (n=884)			Firms with cyclers (n=318)			Firms with no cyclers (n=566)			Difference Tests
Variable	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.	Mean	Median	Std. Dev.	p-Value
VC	0.66	1.00	0.47	0.78	1.00	0.42	0.60	1.00	0.49	<.0001
Ln(1+age)	2.17	2.08	0.89	2.05	1.95	0.82	2.24	2.08	0.92	0.0019
Initial return	31.41	11.28	63.98	37.94	15.07	69.57	27.75	9.27	60.36	0.023
Ln(market cap)	5.40	5.25	1.35	5.59	5.39	1.35	5.29	5.20	1.34	0.0019
Ln(Tobin's Q)	1.29	1.17	0.73	1.38	1.25	0.75	1.23	1.14	0.72	0.0034
UW rank	7.51	8.00	2.25	7.90	8.00	1.85	7.29	8.00	2.42	<.0001
Newcomer01_perc	0.42	0.44	0.37	0.45	0.48	0.32	0.41	0.40	0.39	0.1419
Newcomer02_perc	0.54	0.62	0.34	0.55	0.61	0.29	0.53	0.63	0.37	0.3802
Newcomer03_perc	0.60	0.68	0.33	0.61	0.67	0.28	0.59	0.69	0.36	0.4117
Newcomer04_perc	0.63	0.73	0.33	0.65	0.71	0.28	0.62	0.75	0.35	0.2691

APPENDIX 6: Multivariate Regression Explaining IPO Long-Run Performance

Table 6

Multivariate Regression Explaining IPO Long-Run Performance

Table 6 presets the results of the effect of talent cycling on IPO long-run performance for 884 IPOs from 1985 to 2007. *Cyclers* is defined as a dummy variable equal to one if the firm has at least one cycler and zero otherwise,. *Number of cyclers* is defined as the quartile rank of the number of cyclers in a firm. *Percentage of cyclers* is defined as the quartile rank of the ratio of the number of cyclers to the total number of inventors in a firm. *Cyclers' patent* is defined aa the number of patents made by cyclers. *Cyclers' citation* is defined as the number of citations received by cyclers' patents. *ROA* is the match-adjusted ROA defined as net income divided by total assets. *M/B* is market-to-book ratio measured at the end of the 12th quarter after the IPO. *Survival* is defined as a dummy variable equal to one if the firm remains in the CRSP database for three years after IPO, and zero otherwise. *Merger* is defined as a dummy variable equal to one if the firm listed is due to merges, and zero otherwise.

Panel A. Cycler (dummy)

	AR0,1			AR0,2			AR0,3			AR0,4		
	Market-vw adj.	Market-ew adj.	Size-BM adj.	Market-vw adj.	Market-ew adj.	Size-BM adj.	Market-vw adj.	Market-ew adj.	Size-BM adj.	Market-vw adj.	Market-ew adj.	Size-BM adj.
Cyclers	-12.40*	-13.09*	-17.17*	-22.98*	-24.51**	-32.25**	-31.65*	-33.13*	-61.98**	-21.85	-24.07	-55.40*
	(-1.69)	(-1.80)	(-1.75)	(-1.88)	(-2.01)	(-2.25)	(-1.75)	(-1.84)	(-2.72)	(-0.77)	(-0.85)	(-1.68)
VC	9.139	8.651	20.70*	18.41	17.45	26.30	23.53	21.82	22.77	22.70	17.76	11.60
	(1.09)	(1.04)	(1.85)	(1.31)	(1.25)	(1.60)	(1.14)	(1.05)	(0.87)	(0.70)	(0.54)	(0.31)
Ln(1+age)	2.766	2.596	2.846	8.749	7.866	6.688	11.04	10.19	1.264	6.651	5.198	-3.110
	(0.64)	(0.60)	(0.49)	(1.20)	(1.08)	(0.78)	(1.03)	(0.95)	(0.09)	(0.39)	(0.31)	(-0.16)
Initial return	-0.456***	-0.447***	-0.417***	-0.208*	-0.207*	-0.162	-0.319*	-0.305*	-0.385*	-0.556**	-0.563**	-0.626**
	(-6.48)	(-6.40)	(-4.44)	(-1.77)	(-1.77)	(-1.18)	(-1.84)	(-1.75)	(-1.75)	(-2.03)	(-2.06)	(-1.97)
Ln(market cap)	13.99***	14.10***	9.421*	5.771	5.286	2.084	14.08	15.12	8.588	12.94	13.68	6.226
	(3.40)	(3.46)	(1.71)	(0.84)	(0.77)	(0.26)	(1.39)	(1.49)	(0.67)	(0.81)	(0.86)	(0.34)
Ln(Tobin's Q)	32.39***	32.40***	32.36***	13.44	13.22	30.05**	9.125	9.390	41.96*	43.42	41.63	90.40**
	(4.55)	(4.59)	(3.40)	(1.13)	(1.12)	(2.16)	(0.52)	(0.54)	(1.89)	(1.57)	(1.51)	(2.81)
UW rank	-2.040	-2.119	-3.342	0.694	0.858	-1.545	1.723	1.648	1.404	1.502	2.145	-1.562
	(-1.19)	(-1.24)	(-1.46)	(0.24)	(0.30)	(-0.46)	(0.41)	(0.39)	(0.26)	(0.23)	(0.32)	(-0.20)
Newcomer01_perc	17.59*	17.76*	32.12**									
	(1.92)	(1.95)	(2.62)									
Newcomer02_perc				41.06**	41.25**	52.69**						
				(2.50)	(2.52)	(2.73)						
Newcomer03_perc							54.92**	50.59**	36.58			
							(2.17)	(2.00)	(1.14)			
Newcomer04_perc										139.3***	124.8**	122.4**
										(3.45)	(3.09)	(2.61)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	884	884	883	884	884	883	884	884	884	884	884	884
R-square	0.174	0.182	0.089	0.158	0.188	0.107	0.106	0.140	0.070	0.075	0.120	0.112

Panel B. Number of cyclers (ranked by quartile)

	AR0,1			AR0,2			AR0,3			AR0,4		
	Market-vw adj.	Market-ew adj.	Size-BM adj.	Market-vw adj.	Market-ew adj.	Size-BM adj.	Market-vw adj.	Market-ew adj.	Size-BM adj.	Market-vw adj.	Market-ew adj.	Size-BM adj.
Number of cyclers	-3.552*	-3.716*	-4.607*	-6.244*	-6.682*	-8.442**	-8.480*	-8.760*	-16.13**	-5.928	-6.468	-15.94*
	(-1.73)	(-1.82)	(-1.68)	(-1.82)	(-1.95)	(-2.10)	(-1.67)	(-1.73)	(-2.52)	(-0.74)	(-0.81)	(-1.72)
VC	9.054	8.546	20.46*	18.12	17.15	25.75	23.08	21.30	21.68	22.42	17.43	11.29
	(1.08)	(1.03)	(1.83)	(1.29)	(1.23)	(1.57)	(1.12)	(1.03)	(0.83)	(0.69)	(0.53)	(0.30)
Ln(1+age)	2.813	2.648	2.931	8.859	7.982	6.862	11.20	10.38	1.618	6.761	5.324	-2.885
	(0.65)	(0.61)	(0.50)	(1.22)	(1.10)	(0.80)	(1.04)	(0.97)	(0.12)	(0.40)	(0.31)	(-0.15)
Initial return	-0.455***	-0.446***	-0.417***	-0.206*	-0.206*	-0.161	-0.318*	-0.303*	-0.382*	-0.555**	-0.562**	-0.623*
	(-6.47)	(-6.39)	(-4.43)	(-1.76)	(-1.76)	(-1.17)	(-1.83)	(-1.75)	(-1.74)	(-2.03)	(-2.05)	(-1.96)
Ln(market cap)	14.00***	14.11***	9.362*	5.718	5.234	1.923	13.98	14.99	8.270	12.89	13.61	6.314
	(3.41)	(3.46)	(1.70)	(0.83)	(0.76)	(0.24)	(1.38)	(1.48)	(0.64)	(0.81)	(0.85)	(0.34)
Ln(Tobin's Q)	32.43***	32.45***	32.45***	13.55	13.34	30.24**	9.289	9.573	42.33*	43.53	41.75	90.59**
	(4.56)	(4.60)	(3.41)	(1.14)	(1.13)	(2.17)	(0.53)	(0.55)	(1.91)	(1.58)	(1.51)	(2.82)
UW rank	-2.036	-2.114	-3.339	0.698	0.862	-1.543	1.726	1.649	1.402	1.506	2.148	-1.540
	(-1.19)	(-1.24)	(-1.46)	(0.24)	(0.30)	(-0.46)	(0.41)	(0.39)	(0.26)	(0.23)	(0.32)	(-0.20)
Newcomer01_perc	17.49*	17.66*	31.99**									
	(1.91)	(1.94)	(2.61)									
Newcomer02_perc				40.84**	41.02**	52.44**						
				(2.49)	(2.50)	(2.72)						
Newcomer03_perc							54.62**	50.29**	36.05			
							(2.16)	(1.99)	(1.13)			
Newcomer04_perc										139.0***	124.5**	121.7**
										(3.44)	(3.08)	(2.59)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	884	884	883	884	884	883	884	884	884	884	884	884
R-square	0.174	0.182	0.089	0.158	0.188	0.106	0.106	0.140	0.069	0.075	0.120	0.112

Panel C. Percentage of cyclers (ranked by quartile)

	AR0,1			AR0,2			AR0,3			AR0,4		
	Market-vw adj.	Market-ew adj.	Size-BM adj.	Market-vw adj.	Market-ew adj.	Size-BM adj.	Market-vw adj.	Market-ew adj.	Size-BM adj.	Market-vw adj.	Market-ew adj.	Size-BM adj.
Percentage of cyclers	-3.758*	-3.941*	-5.733**	-5.566	-5.954*	-8.424**	-7.989	-8.155	-16.53**	-5.810	-5.905	-15.46*
	(-1.81)	(-1.92)	(-2.07)	(-1.61)	(-1.72)	(-2.07)	(-1.56)	(-1.59)	(-2.56)	(-0.72)	(-0.73)	(-1.65)
VC	8.943	8.433	20.62*	17.53	16.51	25.28	22.42	20.58	20.93	22.05	16.87	10.23
	(1.07)	(1.02)	(1.85)	(1.25)	(1.18)	(1.54)	(1.09)	(1.00)	(0.80)	(0.68)	(0.52)	(0.27)
Ln(1+age)	2.639	2.466	2.617	8.660	7.769	6.499	10.87	10.05	0.852	6.510	5.095	-3.543
	(0.61)	(0.57)	(0.45)	(1.19)	(1.07)	(0.76)	(1.01)	(0.93)	(0.06)	(0.38)	(0.30)	(-0.18)
Initial return	-0.455***	-0.446***	-0.416***	-0.208*	-0.208*	-0.162	-0.320*	-0.305*	-0.384*	-0.556**	-0.563**	-0.625**
	(-6.47)	(-6.40)	(-4.43)	(-1.77)	(-1.77)	(-1.18)	(-1.84)	(-1.76)	(-1.75)	(-2.03)	(-2.06)	(-1.97)
Ln(market cap)	13.75***	13.85***	9.182*	5.109	4.582	1.257	13.23	14.19	7.058	12.40	13.01	4.989
	(3.36)	(3.41)	(1.68)	(0.75)	(0.67)	(0.16)	(1.31)	(1.40)	(0.55)	(0.78)	(0.82)	(0.27)
Ln(Tobin's Q)	32.66***	32.68***	32.72***	13.97	13.78	30.78**	9.843	10.15	43.35*	43.90	42.17	91.60**
	(4.59)	(4.63)	(3.45)	(1.18)	(1.16)	(2.21)	(0.56)	(0.58)	(1.96)	(1.59)	(1.53)	(2.85)
UW rank	-2.030	-2.108	-3.321	0.692	0.856	-1.538	1.726	1.648	1.426	1.511	2.146	-1.529
	(-1.18)	(-1.24)	(-1.45)	(0.24)	(0.30)	(-0.46)	(0.41)	(0.39)	(0.27)	(0.23)	(0.32)	(-0.20)
Newcomer01_perc	17.75*	17.93**	32.37**									
	(1.94)	(1.97)	(2.64)									
Newcomer02_perc				41.33**	41.54**	53.05**						
				(2.51)	(2.53)	(2.75)						
Newcomer03_perc							55.27**	50.98**	37.17			
							(2.18)	(2.01)	(1.16)			
Newcomer04_perc										139.4***	124.9**	122.6**
										(3.45)	(3.09)	(2.61)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	884	884	883	884	884	883	884	884	884	884	884	884
R-square	0.174	0.182	0.090	0.157	0.187	0.106	0.105	0.139	0.069	0.074	0.120	0.112

Panel D. Cyclers' patent

	AR0,1			AR0,2			AR0,3			AR0,4		
	Market-vw adj.	Market-ew adj.	Size-BM adj.	Market-vw adj.	Market-ew adj.	Size-BM adj.	Market-vw adj.	Market-ew adj.	Size-BM adj.	Market-vw adj.	Market-ew adj.	Size-BM adj.
Cyclers' patent	-9.353*	-9.139*	-6.827	-15.47*	-16.77*	-14.93	-21.73*	-22.20*	-31.17*	-14.27	-15.84	-35.21
	(-1.80)	(-1.77)	(-0.98)	(-1.78)	(-1.94)	(-1.46)	(-1.70)	(-1.73)	(-1.92)	(-0.71)	(-0.79)	(-1.50)
VC	8.860	8.253	19.47*	17.64	16.67	24.27	22.51	20.67	19.15	23.17	18.09	10.24
	(1.06)	(1.00)	(1.74)	(1.26)	(1.20)	(1.48)	(1.09)	(1.00)	(0.73)	(0.71)	(0.56)	(0.27)
Ln(1+age)	2.730	2.582	2.995	8.746	7.853	6.902	11.01	10.19	1.581	7.124	5.641	-2.755
	(0.63)	(0.60)	(0.51)	(1.20)	(1.08)	(0.81)	(1.02)	(0.95)	(0.12)	(0.42)	(0.33)	(-0.14)
Initial return	-0.455***	-0.446***	-0.418***	-0.206*	-0.206*	-0.163	-0.318*	-0.303*	-0.386*	-0.556**	-0.562**	-0.628**
	(-6.46)	(-6.39)	(-4.44)	(-1.76)	(-1.76)	(-1.18)	(-1.83)	(-1.74)	(-1.75)	(-2.04)	(-2.05)	(-1.98)
Ln(market cap)	13.97***	14.02***	8.855	5.568	5.094	1.179	13.82	14.80	7.056	12.43	13.27	4.870
	(3.40)	(3.44)	(1.61)	(0.81)	(0.74)	(0.15)	(1.36)	(1.46)	(0.55)	(0.78)	(0.83)	(0.26)
Ln(Tobin's Q)	31.95***	32.00***	32.27***	12.80	12.51	29.73**	8.221	8.490	41.16*	41.48	39.72	88.07**
	(4.49)	(4.53)	(3.38)	(1.08)	(1.05)	(2.13)	(0.47)	(0.48)	(1.85)	(1.50)	(1.44)	(2.74)
UW rank	-2.047	-2.129	-3.376	0.671	0.835	-1.604	1.690	1.611	1.289	1.278	1.953	-1.876
	(-1.19)	(-1.25)	(-1.47)	(0.23)	(0.29)	(-0.48)	(0.40)	(0.38)	(0.24)	(0.19)	(0.29)	(-0.24)
Newcomer01_perc	17.43*	17.60*	31.98**									
	(1.90)	(1.94)	(2.60)									
Newcomer02_perc				40.92**	41.09**	52.83**						
				(2.49)	(2.51)	(2.73)						
Newcomer03_perc							55.12**	50.82**	37.45			
							(2.18)	(2.01)	(1.17)			
Newcomer04_perc										157.6***	139.6***	147.3**
										(3.77)	(3.33)	(3.03)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	884	884	883	884	884	883	884	884	884	884	884	884
R-square	0.108	0.116	0.014	0.091	0.123	0.032	0.035	0.072	-0.008	0.004	0.052	0.043

Panel E. Cyclers' citation

	AR0,1			AR0,2			AR0,3			AR0,4		
	Market-vw adj.	Market-ew adj.	Size-BM adj.	Market-vw adj.	Market-ew adj.	Size-BM adj.	Market-vw adj.	Market-ew adj.	Size-BM adj.	Market-vw adj.	Market-ew adj.	Size-BM adj.
Cyclers' citation	-2.910	-2.881	-4.083*	-4.910	-5.376*	-6.375*	-5.747	-5.916	-11.96**	-3.303	-3.672	-12.54
	(-1.60)	(-1.59)	(-1.68)	(-1.61)	(-1.77)	(-1.78)	(-1.28)	(-1.31)	(-2.10)	(-0.47)	(-0.52)	(-1.52)
VC	9.395	8.800	21.10*	18.60	17.73	26.23	23.12	21.32	22.41	23.26	18.20	13.27
	(1.12)	(1.05)	(1.88)	(1.32)	(1.26)	(1.59)	(1.11)	(1.03)	(0.85)	(0.71)	(0.56)	(0.35)
Ln(1+age)	2.733	2.581	2.794	8.737	7.839	6.723	11.12	10.30	1.365	7.243	5.773	-2.913
	(0.63)	(0.60)	(0.48)	(1.20)	(1.08)	(0.79)	(1.03)	(0.96)	(0.10)	(0.43)	(0.34)	(-0.15)
Initial return	-0.455***	-0.447***	-0.417***	-0.208*	-0.207*	-0.163	-0.321*	-0.306*	-0.386*	-0.559**	-0.564**	-0.630**
	(-6.47)	(-6.40)	(-4.44)	(-1.77)	(-1.77)	(-1.18)	(-1.84)	(-1.76)	(-1.76)	(-2.04)	(-2.06)	(-1.98)
Ln(market cap)	13.96***	14.02***	9.387*	5.610	5.153	1.692	13.54	14.53	7.729	12.11	12.92	5.327
	(3.40)	(3.44)	(1.71)	(0.82)	(0.75)	(0.21)	(1.33)	(1.43)	(0.60)	(0.76)	(0.81)	(0.29)
Ln(Tobin's Q)	32.22***	32.25***	32.12***	13.19	12.93	29.81**	8.993	9.270	41.57*	42.08	40.38	88.75**
	(4.52)	(4.56)	(3.38)	(1.11)	(1.09)	(2.14)	(0.51)	(0.53)	(1.87)	(1.52)	(1.46)	(2.77)
UW rank	-2.130	-2.211	-3.466	0.539	0.691	-1.753	1.518	1.435	0.994	1.172	1.835	-2.200
	(-1.24)	(-1.30)	(-1.51)	(0.19)	(0.24)	(-0.52)	(0.36)	(0.34)	(0.19)	(0.18)	(0.28)	(-0.28)
Newcomer01_perc	17.62*	17.79*	32.21**									
	(1.92)	(1.96)	(2.63)									
Newcomer02_perc				40.69**	40.84**	52.33**						
				(2.47)	(2.49)	(2.71)						
Newcomer03_perc							55.04**	50.73**	36.69			
							(2.17)	(2.00)	(1.15)			
Newcomer04_perc										157.7***	139.6***	147.0**
										(3.77)	(3.33)	(3.02)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	884	884	883	884	884	883	884	884	884	884	884	884
R-square	0.108	0.116	0.016	0.090	0.123	0.033	0.033	0.070	-0.008	0.003	0.052	0.044

Panel F. Excluding the first year

	AR1,2			AR1,3			AR1,4		
	Market-vw adj.	Market-ew adj.	Size-BM adj.	Market-vw adj.	Market-ew adj.	Size-BM adj.	Market-vw adj.	Market-ew adj.	Size-BM adj.
Cyclers	-7.233	-7.806	-6.647	-20.62	-20.87	-50.83**	-5.403	-6.441	-34.88
	(-0.90)	(-0.98)	(-0.71)	(-1.60)	(-1.63)	(-2.56)	(-0.23)	(-0.28)	(-1.18)
VC	10.43	9.658	11.84	21.92	20.77	23.51	15.92	12.71	4.378
	(1.13)	(1.06)	(1.11)	(1.49)	(1.42)	(1.03)	(0.60)	(0.48)	(0.13)
Ln(1+age)	5.852	5.239	2.792	0.599	0.180	-4.012	-5.709	-6.648	-9.498
	(1.22)	(1.11)	(0.50)	(0.08)	(0.02)	(-0.34)	(-0.41)	(-0.48)	(-0.54)
Initial return	0.0263	0.0169	0.0364	-0.0574	-0.0573	-0.119	-0.217	-0.238	-0.253
	(0.34)	(0.22)	(0.41)	(-0.46)	(-0.47)	(-0.62)	(-0.97)	(-1.06)	(-0.89)
Ln(market cap)	-0.572	-1.062	-0.264	14.92**	15.31**	11.68	7.585	7.743	7.174
	(-0.13)	(-0.24)	(-0.05)	(2.07)	(2.14)	(1.05)	(0.58)	(0.59)	(0.43)
Ln(Tobin's Q)	-10.50	-10.36	2.654	-21.88*	-21.25*	10.71	6.581	5.429	61.05**
	(-1.35)	(-1.34)	(0.29)	(-1.76)	(-1.71)	(0.56)	(0.29)	(0.24)	(2.12)
UW rank	0.173	0.437	-1.396	-1.315	-1.199	0.167	-0.291	0.348	-1.094
	(0.09)	(0.24)	(-0.64)	(-0.44)	(-0.40)	(0.04)	(-0.05)	(0.06)	(-0.16)
Newcomer12_perc	25.03**	24.46**	29.39**						
	(2.42)	(2.40)	(2.46)						
Newcomer13_perc				6.895	3.227	-9.370			
				(0.41)	(0.19)	(-0.36)			
Newcomer14_perc							116.8***	102.6**	104.2**
							(3.75)	(3.29)	(2.63)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	882	882	880	883	883	882	883	883	882
R-square	0.174	0.180	0.070	0.127	0.132	0.089	0.083	0.108	0.097

Panel G. Survival, M/B and ROA three years after IPO

	ROA			M/B			Survival			Merger		
Cyclers	-0.0170*			0.104			0.0176			0.000488		
	(-1.90)			(0.69)			(1.19)			(0.02)		
The number of cyclers		-0.00216			0.0152			0.00321			0.00164	
		(-0.95)			(0.41)			(0.88)			(0.31)	
The percentage of cyclers			-0.0434**			0.143			-0.00360			0.134**
			(-2.31)			(0.45)			(-0.12)			(3.02)
VC	-0.0172*	-0.0189*	-0.0189*	0.0469	0.0554	0.0587	0.0379**	0.0393**	0.0402**	-0.0125	-0.0129	-0.0134
	(-1.66)	(-1.82)	(-1.83)	(0.27)	(0.32)	(0.34)	(2.23)	(2.32)	(2.38)	(-0.50)	(-0.52)	(-0.55)
Ln(1+age)	0.00909*	0.00941*	0.00868	-0.0681	-0.0699	-0.0677	0.0146*	0.0143	0.0142	0.0110	0.0111	0.0136
	(1.71)	(1.77)	(1.63)	(-0.76)	(-0.78)	(-0.76)	(1.66)	(1.62)	(1.60)	(0.85)	(0.86)	(1.05)
Initial return	-0.0000252	-0.0000271	-0.0000288	-0.00516***	-0.00514***	-0.00512***	0.0000736	0.0000743	0.0000771	0.000102	0.000101	0.000107
	(-0.29)	(-0.32)	(-0.34)	(-3.56)	(-3.55)	(-3.54)	(0.52)	(0.52)	(0.54)	(0.49)	(0.48)	(0.52)
Ln(market cap)	0.0283***	0.0279***	0.0270***	-0.0742	-0.0728	-0.0669	0.0260**	0.0261**	0.0271**	0.0141	0.0136	0.0146
	(5.60)	(5.49)	(5.37)	(-0.88)	(-0.86)	(-0.79)	(3.12)	(3.11)	(3.28)	(1.16)	(1.11)	(1.21)
Ln(Tobin's Q)	-0.0179**	-0.0179**	-0.0162*	0.979***	0.980***	0.971***	-0.0163	-0.0159	-0.0167	-0.0198	-0.0194	-0.0244
	(-2.04)	(-2.03)	(-1.84)	(6.65)	(6.64)	(6.57)	(-1.13)	(-1.10)	(-1.15)	(-0.94)	(-0.92)	(-1.16)
UW rank	0.00213	0.00212	0.00224	-0.0579*	-0.0580*	-0.0580*	0.00117	0.00114	0.00125	0.00478	0.00474	0.00435
	(1.01)	(1.01)	(1.06)	(-1.65)	(-1.65)	(-1.65)	(0.34)	(0.33)	(0.36)	(0.94)	(0.93)	(0.86)
Newcomer03_perc	0.0224**	0.0221*	0.0224**	-0.0863	-0.0840	-0.0863	0.00871	0.00933	0.00886	-0.0582**	-0.0580**	-0.0585**
	(2.00)	(1.96)	(2.00)	(-0.46)	(-0.44)	(-0.46)	(0.47)	(0.50)	(0.48)	(-2.14)	(-2.13)	(-2.16)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	861	861	861	856	856	856	884	884	884	884	884	884
R-square	0.228	0.225	0.230	0.221	0.221	0.221	0.108	0.107	0.107	0.072	0.072	0.083

APPENDIX 7: Calendar-Time Factor Model Regressions

Table 7

Calendar-Time Factor Model Regressions Using Fama-French 3-Factor Model (Jan. 1985-Dec. 2007)

Table 7 presents the calendar-time factor model regressions suing Fama-French (1993) 3-factor model for IPO firms in the period of 1985-2007. The model is $R_{pt} - r_{ft} = a + b(R_{mt} - r_{ft}) + sSMB_t + hHML_t + e_t$, where R_{pt} is the return for an equal-weighted calendar-time portfolio of IPOs in month t, r_{ft} is the return on the three-month T-bill in month t, $R_{mt}$is the return on the value-weighted market index in month t, $(R_{mt} - r_{ft})$ is the market risk premium MRP, SMB_t is the return on a value-weighted portfolio of small firms minus the return on a value-weighted portfolio of large firms in month t, and HML_t is the return on a value-weighted portfolio of high book-to-market stocks minus the return on a value-weighted portfolio of high book-to-market stocks in month t. I calculate the returns for the portfolio of IPO firms for the period of 0-6 months after IPO in Panel A, 0-12 months after IPO in Panel B, 0-24 months after IPO in Panel C, 0-36 months after IPO in Panel D and 0-48 months after IPO in Panel E. Each regression uses 276 monthly observations. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

Panel A. 0-6 months after IPO

	(1)	(2)	(3)	(4)	(5)
	Full sample	Firms with no innovation	Firms with innovation	Firms with no cyclers	Firms with cycler
MRP	1.328***	1.293***	1.355***	1.402***	1.354***
	(17.04)	(144.28)	(50.79)	(9.99)	(8.78)
SMB	1.002***	1.004***	1.322***	1.176***	1.060***
	(10.18)	(93.90)	(45.97)	(6.63)	(5.49)
HML	-0.619***	-0.584***	-1.002***	-1.184***	-0.847***
	(-4.94)	(-39.95)	(-27.24)	(-5.31)	(-3.46)
Intercept	0.198	-0.0160	1.513***	1.228**	0.718
	(0.63)	(-0.45)	(14.80)	(2.18)	(1.14)

Panel B. 0-12 months after IPO

	(1)	(2)	(3)	(4)	(5)
	Full sample	Firms with no innovation	Firms with innovation	Firms with no cyclers	Firms with cycler
MRP	1.254***	1.349***	1.214***	1.231***	1.252***
	(26.64)	(16.01)	(5.71)	(12.02)	(10.58)
SMB	1.012***	0.964***	1.056***	1.082***	1.034***
	(15.40)	(8.20)	(4.77)	(8.02)	(6.62)
HML	-0.546***	-0.547***	-0.762**	-1.127***	-0.857***
	(-7.47)	(-3.82)	(-2.52)	(-6.84)	(-4.50)
Intercept	-0.152	0.263	-0.351	0.441	0.206
	(-0.72)	(0.78)	(-0.38)	(1.02)	(0.41)

Panel C. 0-24 months after IPO

	(1) Full sample	(2) Firms with no innovation	(3) Firms with innovation	(4) Firms with no cyclers	(5) Firms with cycler
MRP	1.254***	1.207***	1.365***	1.403***	1.250***
	(26.64)	(23.57)	(22.96)	(20.94)	(14.73)
SMB	1.012***	0.928***	1.242***	1.241***	1.195***
	(15.40)	(12.99)	(15.03)	(13.33)	(10.13)
HML	-0.546***	-0.460***	-0.834***	-0.849***	-0.880***
	(-7.47)	(-5.79)	(-9.09)	(-8.20)	(-6.71)
Intercept	-0.152	-0.247	0.329	0.342	0.320
	(-0.72)	(-1.08)	(1.24)	(1.14)	(0.84)

Panel D. 0-36 months after IPO

	(1) Full sample	(2) Firms with no innovation	(3) Firms with innovation	(4) Firms with no cyclers	(5) Firms with cycler
MRP	1.357***	1.204***	1.400***	1.427***	1.309***
	(19.66)	(25.09)	(22.51)	(20.65)	(17.31)
SMB	1.138***	0.945***	1.218***	1.193***	1.245***
	(12.30)	(13.81)	(13.79)	(12.16)	(11.59)
HML	-0.541***	-0.331***	-0.730***	-0.723***	-0.792***
	(-4.69)	(-4.42)	(-7.55)	(-6.73)	(-6.73)
Intercept	-0.261	-0.122	0.593**	0.693**	0.168
	(-0.92)	(-0.56)	(2.10)	(2.21)	(0.49)

Panel E. 0-48 months after IPO

	(1) Full sample	(2) Firms with no innovation	(3) Firms with innovation	(4) Firms with no cyclers	(5) Firms with cycler
MRP	1.259***	1.203***	1.408***	1.416***	1.390***
	(29.01)	(26.64)	(25.45)	(24.37)	(19.95)
SMB	1.046***	0.951***	1.327***	1.293***	1.383***
	(16.71)	(14.59)	(16.68)	(15.47)	(13.80)
HML	-0.305***	-0.221**	-0.570***	-0.570***	-0.533***
	(-4.47)	(-3.11)	(-6.57)	(-6.25)	(-4.88)
Intercept	0.0435	-0.0818	0.536**	0.575**	0.304
	(0.22)	(-0.40)	(2.14)	(2.19)	(0.96)

APPENDIX 8: Calendar-Time Factor Model Regressions Purged IPO and SEO Firms

Table 8
Calendar-Time Factor Model Regressions Using Fama-French 3-Factor Model Purged IPO and SEO Firms (Jan. 1985-Dec. 2003)

Table 8 presents the calendar-time factor model regressions using Fama-French (1993) 3-factor model purged IPO and SEO firms for IPO firms in the period of 1985-2007. The model is $R_{pt} - r_{ft} = a + b(R_{mt} - r_{ft}) + sSMB_t + hHML_t + e_t$, where R_{pt} is the return for an equal-weighted calendar-time portfolio of IPOs in month t, r_{ft} is the return on the three-month T-bill in month t, $R_{mt}$is the return on the value-weighted market index in month t, $(R_{mt} - r_{ft})$ is the market risk premium MRP, SMB_t is the return on a value-weighted portfolio of small firms minus the return on a value-weighted portfolio of large firms in month t purged IPO and SEO firms, and HML_t is the return on a value-weighted portfolio of high book-to-market stocks minus the return on a value-weighted portfolio of high book-to-market stocks in month t purged IPO and SEO firms. I calculate the returns for the portfolio of IPO firms for the period of 0-6 months after IPO in Panel A, 0-12 months after IPO in Panel B, 0-24 months after IPO in Panel C, 0-36 months after IPO in Panel D and 0-48 months after IPO in Panel E. Each regression uses 228 monthly observations. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

Panel A. 0-6 month after IPO

	(1)	(2)	(3)	(4)	(5)
	Full sample	Firms with no innovation	Firms with innovation	Firms with no cyclers	Firms with cycler
MRP	1.374***	1.366***	1.503***	1.422***	1.510***
	(14.54)	(132.62)	(46.04)	(8.40)	(9.08)
SMB	1.106***	1.231***	1.577***	1.219***	1.244***
	(8.74)	(96.27)	(41.92)	(5.38)	(5.61)
HML	-0.760***	-0.656***	-0.975***	-1.398***	-0.785**
	(-4.82)	(-39.35)	(-21.88)	(-5.01)	(-2.87)
Intercept	0.149	-0.167***	1.481***	1.547**	0.899
	(0.38)	(-4.16)	(11.93)	(2.23)	(1.29)

Panel B. 0-12 month after IPO

	(1)	(2)	(3)	(4)	(5)
	Full sample	Firms with no innovation	Firms with innovation	Firms with no cyclers	Firms with cycler
MRP	1.351***	1.384***	1.249***	1.349***	1.380***
	(20.42)	(13.33)	(5.46)	(10.55)	(9.97)
SMB	1.150***	0.941***	1.512***	1.295***	1.050***
	(12.98)	(6.31)	(5.78)	(7.60)	(5.67)
HML	-0.641***	-0.635***	-0.881**	-1.167***	-0.971***
	(-5.81)	(-3.41)	(-2.81)	(-5.50)	(-4.24)
Intercept	-0.472*	0.263	-1.089	0.539	-0.0616
	(-1.74)	(0.62)	(-1.07)	(1.03)	(-0.11)

Panel C. 0-24 month after IPO

	(1) Full sample	(2) Firms with no innovation	(3) Firms with innovation	(4) Firms with no cyclers	(5) Firms with cycler
MRP	1.459***	1.290***	1.459***	1.484***	1.429***
	(16.08)	(18.76)	(16.08)	(14.93)	(13.10)
SMB	1.315***	1.084***	1.315***	1.316***	1.314***
	(10.87)	(11.77)	(10.87)	(9.94)	(9.05)
HML	-0.978***	-0.569***	-0.978***	-1.004***	-0.907***
	(-6.49)	(-4.96)	(-6.49)	(-6.09)	(-5.01)
Intercept	0.300	-0.610**	0.300	0.401	0.0716
	(0.81)	(-2.16)	(0.81)	(0.98)	(0.16)

Panel D. 0-36 month after IPO

	(1) Full sample	(2) Firms with no innovation	(3) Firms with innovation	(4) Firms with no cyclers	(5) Firms with cycler
MRP	1.263***	1.295***	1.461***	1.485***	1.430***
	(27.43)	(18.54)	(16.27)	(15.77)	(13.57)
SMB	1.020***	1.068***	1.321***	1.319***	1.279***
	(15.53)	(11.41)	(11.04)	(10.51)	(9.11)
HML	-0.415***	-0.458***	-0.925***	-0.901***	-0.941***
	(-5.77)	(-3.93)	(-6.20)	(-5.76)	(-5.37)
Intercept	0.0181	-0.412	0.447	0.500	0.371
	(0.09)	(-1.43)	(1.21)	(1.29)	(0.86)

Panel E. 0-48 month after IPO

	(1) Full sample	(2) Firms with no innovation	(3) Firms with innovation	(4) Firms with no cyclers	(5) Firms with cycler
MRP	1.338***	1.288***	1.433***	1.437***	1.448***
	(20.14)	(19.55)	(16.31)	(15.98)	(14.21)
SMB	1.149***	1.071***	1.372***	1.344***	1.394***
	(12.91)	(12.14)	(11.72)	(11.22)	(10.28)
HML	-0.465***	-0.348**	-0.890***	-0.876***	-0.884***
	(-4.20)	(-3.17)	(-6.10)	(-5.87)	(-5.23)
Intercept	-0.138	-0.321	0.621*	0.643*	0.628
	(-0.51)	(-1.18)	(1.72)	(1.74)	(1.50)

APPENDIX 9: Talent Cycling and IPO Long-Run Performance 2SLS Results

Table 9

Talent Cycling and IPO Long-Run Performance--2SLS Results

Table 9 presents the results of the effect of talent cycling on IPO long-run performance for 884 IPOs from 1985 to 2007 from 2SLS results. *Cyclers* is defined as a dummy variable equal to one if the firm has at least one cycler and zero otherwise. The instrument variable is *IDD* defined as a dummy variable equal to one if the state adopts the IDD by the state court. *VC* is a dummy variable equal to one if the firm is VC-backed and zero otherwise. Ln(1+age) is from Loughran and Ritter (2004) measured as the natural logarithm of one plus the number of years from founding year to IPO year. *Initial return* is defined as the closing price one day after the offering date divided by offering price minus one. *Ln(Market cap)* is defined as the natural logarithm of offer price multiplying the total number of post-IPO shares. *Ln (Tobin's Q)* is defined as the natural logarithm of market value of assets over the book value of assets. *UW rank* is the underwritter ranking from Loughran and Ritter (2004) on a 1-9 scale. *Newcomer01_perc* is the ratio of the number of newcomers to the total number of inventors in the firm one year after IPO. Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

Panel A. Including the first year

	AR0,1 (market-vw adj.)	AR0,1 (market-ew adj.)	AR0,1 (size-BM adj.)	AR0,2 (market-vw adj.)	AR0,2 (market-ew adj.)	AR0,2 (size-BM adj.)	AR0,3 (market-vw adj.)	AR0,3 (market-ew adj.)	AR0,3 (size-BM adj.)	AR0,4 (market-vw adj.)	AR0,4 (market-ew adj.)	AR0,4 (size-BM adj.)
Cycler	-3.645	-3.462	5.789	-5.521	-5.473	-5.837	-19.39**	-18.95**	-18.74	-42.78***	-43.76***	-43.20**
	(-1.26)	(-1.20)	(1.47)	(-1.14)	(-1.13)	(-1.02)	(-2.09)	(-2.04)	(-1.58)	(-3.71)	(-3.80)	(-3.17)
VC	11.09	10.30	9.919	16.41	15.95	23.18	35.18	33.23	31.33	71.71**	65.43*	53.28
	(1.23)	(1.15)	(0.81)	(1.07)	(1.05)	(1.29)	(1.52)	(1.43)	(1.06)	(2.02)	(1.85)	(1.27)
Ln(1+age)	2.117	2.153	3.018	9.985	9.132	9.175	8.832	8.161	0.620	6.447	5.256	-3.840
	(0.48)	(0.49)	(0.50)	(1.33)	(1.22)	(1.04)	(0.80)	(0.74)	(0.04)	(0.37)	(0.30)	(-0.19)
Initial retrun	-0.441***	-0.432***	-0.444***	-0.209*	-0.211*	-0.191	-0.337*	-0.323*	-0.452**	-0.537*	-0.544*	-0.700**
	(-6.20)	(-6.12)	(-4.60)	(-1.74)	(-1.76)	(-1.35)	(-1.89)	(-1.81)	(-1.99)	(-1.93)	(-1.95)	(-2.12)
Ln(market cap)	14.10**	14.15***	5.546	7.390	6.870	3.246	20.48*	21.29*	12.90	32.67*	34.30**	25.26
	(3.27)	(3.31)	(0.95)	(1.01)	(0.94)	(0.38)	(1.88)	(1.96)	(0.93)	(1.93)	(2.03)	(1.26)
Ln(Tobin's Q)	32.21***	32.30***	35.49***	9.114	9.030	24.11*	5.038	5.564	35.77	38.65	36.31	79.98**
	(4.46)	(4.50)	(3.62)	(0.75)	(0.74)	(1.67)	(0.28)	(0.31)	(1.55)	(1.37)	(1.28)	(2.39)
UW rank	-1.934	-2.030	-3.881	0.239	0.433	-1.228	1.351	1.193	1.967	1.879	2.670	0.127
	(-1.11)	(-1.17)	(-1.64)	(0.08)	(0.15)	(-0.35)	(0.31)	(0.27)	(0.35)	(0.27)	(0.39)	(0.02)
Newcomer01_perc	15.64*	15.41*	30.01**									
	(1.68)	(1.67)	(2.38)									
Newcomer02_perc				41.45**	41.50**	56.72**						
				(2.47)	(2.48)	(2.87)						
Newcomer03_perc							58.90**	54.74**	47.22			
							(2.27)	(2.11)	(1.43)			
Newcomer04_perc										145.1***	131.8**	139.7**
										(3.54)	(3.22)	(2.88)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	876	876	875	876	876	875	876	876	876	876	876	876
R-square	0.204	0.212	0.097	0.171	0.200	0.110	0.119	0.151	0.066	0.098	0.144	0.104

Panel B. Excluding the first year

	AR1,2 (market-vw adj.)	AR1,2 (market-ew adj.)	AR1,2 (size-BM adj.)	AR1,3 (market-vw adj.)	AR1,3 (market-ew adj.)	AR1,3 (size-BM adj.)	AR1,4 (market-vw adj.)	AR1,4 (market-ew adj.)	AR1,4 (size-BM adj.)
Cycler	-1.751	-1.827	-2.995	-14.41**	-14.46**	-23.34**	-37.41***	-38.62***	-42.14**
	(-0.51)	(-0.54)	(-0.75)	(-2.61)	(-2.63)	(-2.69)	(-3.73)	(-3.85)	(-3.29)
VC	6.104	5.544	14.21	26.63	25.66	36.96	48.77*	45.07	36.90
	(0.61)	(0.56)	(1.21)	(1.65)	(1.59)	(1.45)	(1.67)	(1.54)	(0.99)
Ln(1+age)	7.438	6.574	5.168	-0.529	-1.144	-4.427	-4.075	-5.140	-5.468
	(1.52)	(1.36)	(0.90)	(-0.07)	(-0.15)	(-0.36)	(-0.29)	(-0.36)	(-0.30)
Initial retrun	0.00289	-0.00770	0.0226	-0.0508	-0.0505	-0.124	-0.168	-0.186	-0.261
	(0.04)	(-0.10)	(0.25)	(-0.40)	(-0.40)	(-0.63)	(-0.74)	(-0.82)	(-0.90)
Ln(market cap)	0.659	0.176	2.176	20.07**	20.47**	20.40*	23.50*	24.56*	25.43
	(0.14)	(0.04)	(0.39)	(2.63)	(2.70)	(1.70)	(1.71)	(1.79)	(1.45)
Ln(Tobin's Q)	-11.07	-10.97	0.617	-27.04**	-26.40**	0.148	-1.698	-3.635	47.17
	(-1.39)	(-1.40)	(0.07)	(-2.11)	(-2.07)	(0.01)	(-0.07)	(-0.16)	(1.60)
UW rank	-0.395	-0.100	-0.786	-2.273	-2.168	1.512	-0.625	0.168	1.326
	(-0.21)	(-0.05)	(-0.35)	(-0.73)	(-0.70)	(0.31)	(-0.11)	(0.03)	(0.19)
Newcomer11_perc	24.89**	24.30**	28.00**						
	(2.28)	(2.26)	(2.20)						
Newcomer12_perc				15.14	11.76	-0.344			
				(0.86)	(0.67)	(-0.01)			
Newcomer13_perc							141.5***	126.9***	126.5**
							(4.40)	(3.95)	(3.08)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	874	874	872	875	875	874	875	875	874
R-square	0.202	0.209	0.086	0.148	0.151	0.082	0.113	0.138	0.118

APPENDIX 10: Propensity Score Matching Results

Table 10

Talent Cycling and IPO Long-Run Performance--Propensity Score Matching Results

Table 10 presents the results of the effect of talent cycling on IPO long-run performance from 1985 to 2007 from propensity score matching results. *Cyclers* is defined as a dummy variable equal to one if the firm has at least one cycler and zero otherwise. Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

	AR0,1 (market-vw adj.)	AR0,1 (market-ew adj.)	AR0,1 (size-BM adj.)	AR0,2 (market-vw adj.)	AR0,2 (market-ew adj.)	AR0,2 (size-BM adj.)	AR0,3 (market-vw adj.)	AR0,3 (market-ew adj.)	AR0,3 (size-BM adj.)	AR0,4 (market-vw adj.)	AR0,4 (market-ew adj.)	AR0,4 (size-BM adj.)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Cycler	-11.23*	-12.41**	-15.13*	-20.95**	-22.10**	-28.77**	-35.16**	-34.83**	-67.02**	-26.95	-25.68	-61.17**
	(-1.78)	(-1.97)	(-1.65)	(-2.11)	(-2.25)	(-2.22)	(-2.27)	(-2.23)	(-2.61)	(-1.40)	(-1.30)	(-2.06)
Nearest matching	1	1	1	1	1	1	1	1	1	1	1	1
Other control variables	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
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
Observations	636	636	636	636	636	636	636	636	636	636	636	636

APPENDIX 11: Robustness Tests

Table 11

Talent Cycling and IPO Long-Run Performance--Robustness Tests

This table presents the robustness tests of the effect of talent cycling on IPO long-run performance. In panel A, *Number of employees* is defined as the differences between the number of employees one year after IPO and one year before IPO over total assets. In Panel B, *Salary expense* is defined as the quartile rank of the differences between the salary expenses one year after IPO and one year before IPO. The missing value of salary expenses is set to zero. In Panel C, bubble years (1999 and 2000) are excluded. In Panel D, *Hot market* is defined as a dummy variable equal to one if the number of IPOs in a year is greater than the median number of IPO in the sample by year. Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

Panel A. Number of employees

	AR0,1 (market-vw adj.)	AR0,1 (market-ew adj.)	AR0,1 (size-BM adj.)	AR0,2 (market-vw adj.)	AR0,2 (market-ew adj.)	AR0,2 (size-BM adj.)	AR0,3 (market-vw adj.)	AR0,3 (market-ew adj.)	AR0,3 (size-BM adj.)	AR0,4 (market-vw adj.)	AR0,4 (market-ew adj.)	AR0,4 (size-BM adj.)
Cycler	-11.34	-12.14	-12.16	-21.45	-22.87*	-28.16*	-23.28	-24.83*	-46.75**	-26.33	-29.54	-54.25
	(-1.42)	(-1.53)	(-1.12)	(-1.65)	(-1.76)	(-1.83)	(-1.58)	(-1.69)	(-2.23)	(-0.82)	(-0.92)	(-1.46)
Number of employees	3854.0**	3719.0**	515.5	2682.0	2461.8	2252.7	1868.9	1620.5	1561.4	-25.15	-333.2	3263.0
	(2.76)	(2.69)	(0.27)	(1.18)	(1.09)	(0.84)	(0.73)	(0.63)	(0.43)	(-0.00)	(-0.06)	(0.50)
VC	7.207	6.889	17.64	15.20	14.47	17.85	9.358	8.464	3.542	27.66	23.81	10.35
	(0.78)	(0.75)	(1.41)	(1.01)	(0.96)	(1.00)	(0.55)	(0.50)	(0.15)	(0.74)	(0.64)	(0.24)
Ln(1+age)	1.615	1.663	3.792	4.383	3.459	5.591	2.974	2.894	-1.755	0.685	-1.583	-4.433
	(0.32)	(0.33)	(0.56)	(0.53)	(0.42)	(0.58)	(0.32)	(0.31)	(-0.13)	(0.03)	(-0.08)	(-0.19)
Initial return	-0.466***	-0.456***	-0.444***	-0.235*	-0.230*	-0.186	-0.280*	-0.255*	-0.331	-0.653**	-0.638**	-0.685*
	(-5.93)	(-5.83)	(-4.18)	(-1.84)	(-1.80)	(-1.24)	(-1.93)	(-1.76)	(-1.60)	(-2.07)	(-2.02)	(-1.87)
Ln(market cap)	15.89***	15.91***	9.560	8.172	7.117	0.170	12.49	12.63	4.241	15.67	14.95	3.570
	(3.49)	(3.52)	(1.55)	(1.10)	(0.96)	(0.02)	(1.49)	(1.51)	(0.36)	(0.86)	(0.82)	(0.17)
Ln(Tobin's Q)	31.72***	31.82***	36.55***	11.87	11.72	33.82**	1.983	2.206	37.96*	44.72	42.10	93.03**
	(4.05)	(4.09)	(3.45)	(0.93)	(0.92)	(2.25)	(0.14)	(0.15)	(1.85)	(1.42)	(1.34)	(2.56)
UW rank	-2.787	-2.846	-4.281*	-0.451	0.00269	-2.921	0.606	0.704	-0.633	-0.278	0.704	-4.825
	(-1.48)	(-1.53)	(-1.69)	(-0.15)	(0.00)	(-0.81)	(0.18)	(0.20)	(-0.13)	(-0.04)	(0.09)	(-0.55)
Newcomer01_perc	15.86	16.19	35.60**									
	(1.56)	(1.61)	(2.59)									
Newcomer02_perc				34.85**	35.33**	55.37**						
				(1.98)	(2.01)	(2.67)						
Newcomer03_perc							32.46	27.72	19.17			
							(1.56)	(1.33)	(0.65)			
Newcomer04_perc										146.0**	128.6**	132.8**
										(3.19)	(2.81)	(2.51)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	770	770	769	770	770	769	770	770	770	770	770	770
R-square	0.185	0.191	0.089	0.162	0.188	0.104	0.102	0.150	0.078	0.072	0.114	0.112

Panel B. Salary expense (ranked by quartile)

	AR0,1 (market-vw adj.)	AR0,1 (market-ew adj.)	AR0,1 (size-BM adj.)	AR0,2 (market-vw adj.)	AR0,2 (market-ew adj.)	AR0,2 (size-BM adj.)	AR0,3 (market-vw adj.)	AR0,3 (market-ew adj.)	AR0,3 (size-BM adj.)	AR0,4 (market-vw adj.)	AR0,4 (market-ew adj.)	AR0,4 (size-BM adj.)
Cycler	-12.24*	-12.97*	-17.35*	-22.35*	-23.91*	-31.86**	-30.35*	-31.91*	-58.55**	-21.41	-23.66	-55.51*
	(-1.67)	(-1.78)	(-1.77)	(-1.82)	(-1.96)	(-2.21)	(-1.68)	(-1.76)	(-2.57)	(-0.75)	(-0.83)	(-1.67)
Salary expense	-15.70	-11.74	17.05	-58.36	-55.64	-36.12	-120.1	-113.2	-318.0**	-42.11	-38.60	9.680
	(-0.35)	(-0.26)	(0.28)	(-0.77)	(-0.74)	(-0.41)	(-1.08)	(-1.01)	(-2.26)	(-0.24)	(-0.22)	(0.05)
VC	9.160	8.667	20.68*	18.47	17.51	26.33	23.61	21.89	22.98	22.73	17.79	11.60
	(1.09)	(1.04)	(1.85)	(1.32)	(1.25)	(1.60)	(1.14)	(1.06)	(0.88)	(0.70)	(0.54)	(0.31)
Ln(1+age)	2.801	2.622	2.808	8.880	7.991	6.770	11.27	10.42	1.884	6.735	5.275	-3.129
	(0.64)	(0.61)	(0.48)	(1.22)	(1.10)	(0.79)	(1.05)	(0.97)	(0.14)	(0.40)	(0.31)	(-0.16)
Initial return	-0.455***	-0.446***	-0.418***	-0.205*	-0.205*	-0.161	-0.315*	-0.300*	-0.372*	-0.555**	-0.561**	-0.627**
	(-6.46)	(-6.39)	(-4.45)	(-1.74)	(-1.75)	(-1.17)	(-1.81)	(-1.73)	(-1.70)	(-2.02)	(-2.05)	(-1.97)
Ln(market cap)	13.95***	14.07***	9.468*	5.558	5.083	1.951	13.65	14.71	7.432	12.79	13.54	6.260
	(3.39)	(3.45)	(1.72)	(0.81)	(0.74)	(0.24)	(1.34)	(1.45)	(0.58)	(0.80)	(0.85)	(0.34)
Ln(Tobin's Q)	32.29***	32.33***	32.46***	13.12	12.92	29.86**	8.474	8.776	40.24*	43.19	41.41	90.45**
	(4.53)	(4.57)	(3.41)	(1.10)	(1.09)	(2.14)	(0.48)	(0.50)	(1.82)	(1.56)	(1.50)	(2.81)
UW rank	-2.041	-2.119	-3.342	0.683	0.848	-1.551	1.705	1.631	1.357	1.496	2.139	-1.561
	(-1.19)	(-1.24)	(-1.46)	(0.24)	(0.30)	(-0.46)	(0.40)	(0.39)	(0.25)	(0.22)	(0.32)	(-0.20)
Newcomer01_perc	17.58*	17.75*	32.13**									
	(1.92)	(1.95)	(2.62)									
Newcomer02_perc				41.90**	42.05**	53.21**						
				(2.54)	(2.56)	(2.75)						
Newcomer03_perc							56.68**	52.24**	41.21			
							(2.24)	(2.06)	(1.29)			
Newcomer04_perc										139.9***	125.3**	122.3**
										(3.46)	(3.10)	(2.60)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	884	884	883	884	884	883	884	884	884	884	884	884
R-square	0.174	0.182	0.089	0.159	0.189	0.107	0.107	0.141	0.076	0.075	0.120	0.112

Panel C. Excluding bubble period

	AR0,1 (market-vw adj.)	AR0,1 (market-ew adj.)	AR0,1 (size-BM adj.)	AR0,2 (market-vw adj.)	AR0,2 (market-ew adj.)	AR0,2 (size-BM adj.)	AR0,3 (market-vw adj.)	AR0,3 (market-ew adj.)	AR0,3 (size-BM adj.)	AR0,4 (market-vw adj.)	AR0,4 (market-ew adj.)	AR0,4 (size-BM adj.)
Cycler	-3.085	-4.173	-11.83	-26.76*	-28.51*	-36.66**	-42.08*	-42.80*	-77.09**	-28.94	-29.62	-77.24*
	(-0.46)	(-0.62)	(-1.30)	(-1.74)	(-1.86)	(-2.08)	(-1.83)	(-1.87)	(-2.70)	(-0.79)	(-0.80)	(-1.82)
VC	6.832	6.352	19.53*	23.30	22.31	31.85	31.28	29.20	30.90	30.93	25.69	17.91
	(0.92)	(0.86)	(1.96)	(1.37)	(1.32)	(1.64)	(1.23)	(1.15)	(0.98)	(0.76)	(0.63)	(0.38)
Ln(1+age)	0.0402	-0.116	-5.003	7.039	6.124	1.866	9.988	9.063	-3.179	5.263	4.159	-9.621
	(0.01)	(-0.03)	(-1.00)	(0.83)	(0.72)	(0.19)	(0.79)	(0.72)	(-0.20)	(0.26)	(0.21)	(-0.41)
Initial return	-0.566***	-0.542***	-0.352**	-0.164	-0.178	0.123	-0.565	-0.549	-0.528	-0.987	-0.958	-0.936
	(-4.35)	(-4.21)	(-2.02)	(-0.55)	(-0.60)	(0.36)	(-1.28)	(-1.25)	(-0.96)	(-1.40)	(-1.36)	(-1.15)
Ln(market cap)	12.27***	12.34***	6.866	7.022	6.643	-1.602	19.14	19.82	9.032	17.87	17.99	6.231
	(3.40)	(3.46)	(1.42)	(0.85)	(0.81)	(-0.17)	(1.56)	(1.62)	(0.59)	(0.91)	(0.92)	(0.28)
Ln(Tobin's Q)	22.41**	22.50**	21.06**	16.85	16.88	21.96	22.56	22.36	45.69	70.48*	68.52*	112.0**
	(3.17)	(3.22)	(2.23)	(1.05)	(1.05)	(1.20)	(0.94)	(0.94)	(1.54)	(1.84)	(1.79)	(2.54)
UW rank	-2.612*	-2.668*	-2.871	0.416	0.590	-1.490	1.191	1.136	1.398	1.213	1.638	-1.697
	(-1.79)	(-1.85)	(-1.47)	(0.13)	(0.18)	(-0.39)	(0.24)	(0.23)	(0.23)	(0.15)	(0.21)	(-0.19)
Newcomer01_perc	15.57*	15.46*	15.80									
	(1.87)	(1.88)	(1.42)									
Newcomer02_perc				48.45**	48.90**	58.07**						
				(2.40)	(2.43)	(2.51)						
Newcomer03_perc							63.74**	60.69*	35.91			
							(2.04)	(1.94)	(0.92)			
Newcomer04_perc										173.2***	160.1**	150.0**
										(3.41)	(3.15)	(2.57)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	700	700	699	700	700	699	700	700	700	700	700	700
R-square	0.125	0.148	0.080	0.164	0.192	0.102	0.115	0.145	0.073	0.088	0.126	0.119

Panel D. Hot market

	AR0,1 (market-vw adj.)	AR0,1 (market-ew adj.)	AR0,1 (size-BM adj.)	AR0,2 (market-vw adj.)	AR0,2 (market-ew adj.)	AR0,2 (size-BM adj.)	AR0,3 (market-vw adj.)	AR0,3 (market-ew adj.)	AR0,3 (size-BM adj.)	AR0,4 (market-vw adj.)	AR0,4 (market-ew adj.)	AR0,4 (size-BM adj.)
Cycler	-12.40*	-13.09*	-17.17*	-22.98*	-24.51**	-32.25**	-31.65*	-33.13*	-61.98**	-21.85	-24.07	-55.40*
	(-1.69)	(-1.80)	(-1.75)	(-1.88)	(-2.01)	(-2.25)	(-1.75)	(-1.84)	(-2.72)	(-0.77)	(-0.85)	(-1.68)
Hot market	43.19	42.44	68.12*	9.257	18.50	54.20	-17.49	15.32	58.02	-42.96	-1.184	68.59
	(1.42)	(1.40)	(1.67)	(0.18)	(0.36)	(0.91)	(-0.23)	(0.20)	(0.61)	(-0.36)	(-0.01)	(0.50)
VC	9.139	8.651	20.70*	18.41	17.45	26.30	23.53	21.82	22.77	22.70	17.76	11.60
	(1.09)	(1.04)	(1.85)	(1.31)	(1.25)	(1.60)	(1.14)	(1.05)	(0.87)	(0.70)	(0.54)	(0.31)
Ln(1+age)	2.766	2.596	2.846	8.749	7.866	6.688	11.04	10.19	1.264	6.651	5.198	-3.110
	(0.64)	(0.60)	(0.49)	(1.20)	(1.08)	(0.78)	(1.03)	(0.95)	(0.09)	(0.39)	(0.31)	(-0.16)
Initial return	-0.456***	-0.447***	-0.417***	-0.208*	-0.207*	-0.162	-0.319*	-0.305*	-0.385*	-0.556**	-0.563**	-0.626**
	(-6.48)	(-6.40)	(-4.44)	(-1.77)	(-1.77)	(-1.18)	(-1.84)	(-1.75)	(-1.75)	(-2.03)	(-2.06)	(-1.97)
Ln(market cap)	13.99***	14.10***	9.421*	5.771	5.286	2.084	14.08	15.12	8.588	12.94	13.68	6.226
	(3.40)	(3.46)	(1.71)	(0.84)	(0.77)	(0.26)	(1.39)	(1.49)	(0.67)	(0.81)	(0.86)	(0.34)
Ln(Tobin's Q)	32.39***	32.40***	32.36***	13.44	13.22	30.05**	9.125	9.390	41.96*	43.42	41.63	90.40**
	(4.55)	(4.59)	(3.40)	(1.13)	(1.12)	(2.16)	(0.52)	(0.54)	(1.89)	(1.57)	(1.51)	(2.81)
UW rank	-2.040	-2.119	-3.342	0.694	0.858	-1.545	1.723	1.648	1.404	1.502	2.145	-1.562
	(-1.19)	(-1.24)	(-1.46)	(0.24)	(0.30)	(-0.46)	(0.41)	(0.39)	(0.26)	(0.23)	(0.32)	(-0.20)
Newcomer01_perc	17.59*	17.76*	32.12**									
	(1.92)	(1.95)	(2.62)									
Newcomer02_perc				41.06**	41.25**	52.69**						
				(2.50)	(2.52)	(2.73)						
Newcomer03_perc							54.92**	50.59**	36.58			
							(2.17)	(2.00)	(1.14)			
Newcomer04_perc										139.3***	124.8**	122.4**
										(3.45)	(3.09)	(2.61)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	884	884	883	884	884	883	884	884	884	884	884	884
R-square	0.174	0.182	0.089	0.158	0.188	0.107	0.106	0.140	0.070	0.075	0.120	0.112

APPENDIX 12: Cumulative Abnormal Return

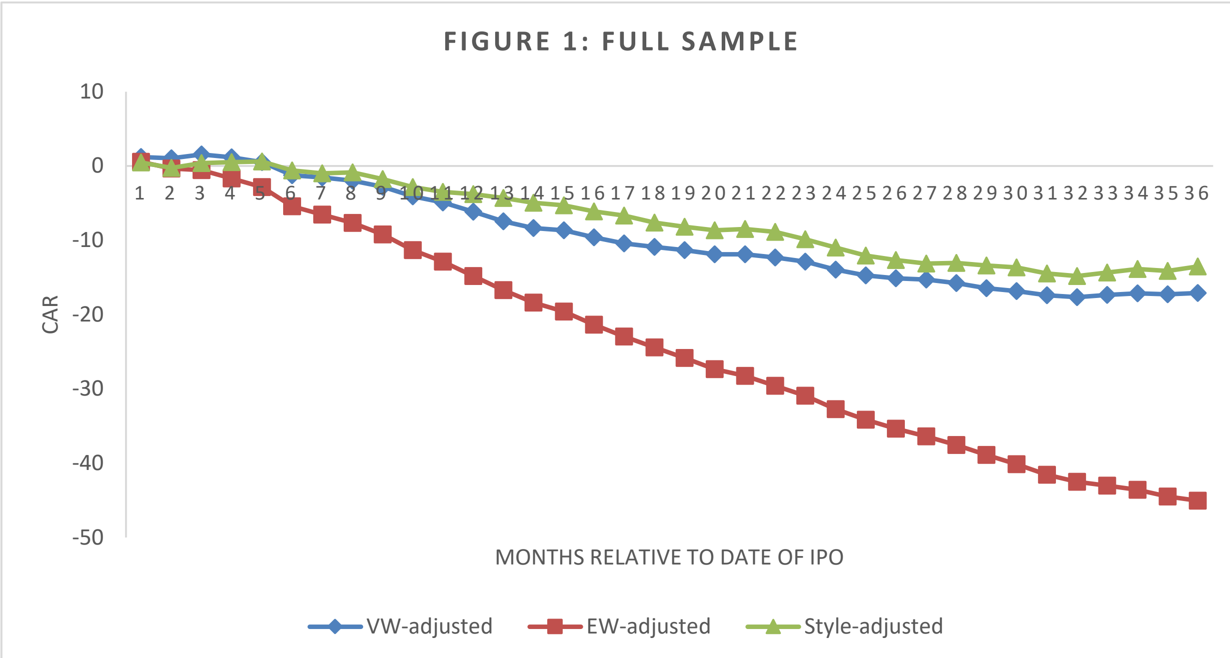

Figure 1. Cumulative buy-and-hold benchmark-adjusted returns for the full sample, 3,833 IPO firms, from 1985 to 2007 with monthly rebalancing. The benchmarks are CRSP value-weighted index, CRSP equal-weighted index and a portfolio of non-IPO firms matched to IPO firms on size and market-to-book (style-matched firms).

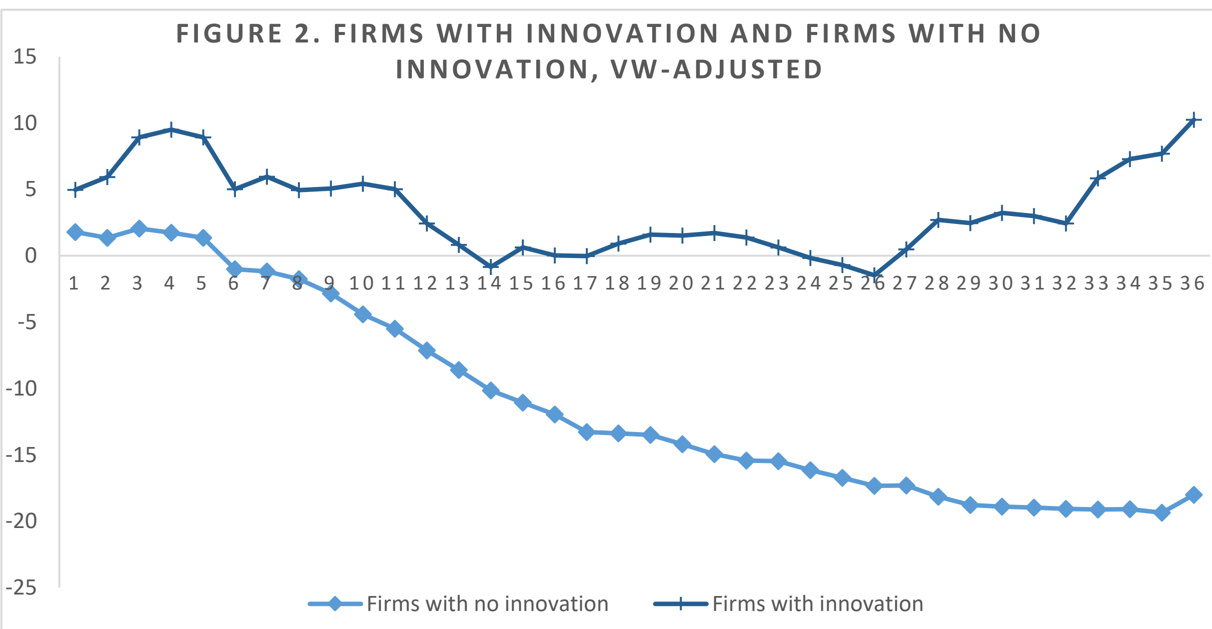

Figure 2. Cumulative buy-and-hold market-value-weighted-adjusted returns for firms with no innovation (2,949 firms) and firms with innovation (884 firms) from 1985 to 2007 with monthly rebalancing.

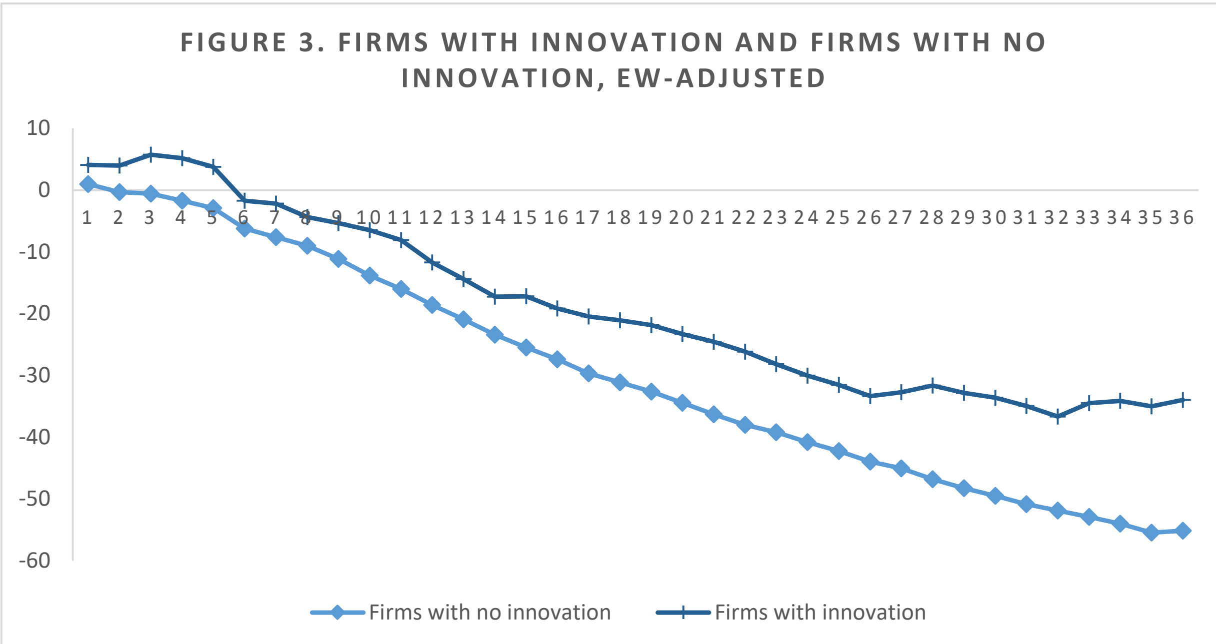

Figure 3. Cumulative buy-and-hold market-equal-weighted-adjusted returns for firms with no innovation (2,949 firms) and firms with innovation (884 firms) from 1985 to 2007 with monthly rebalancing.

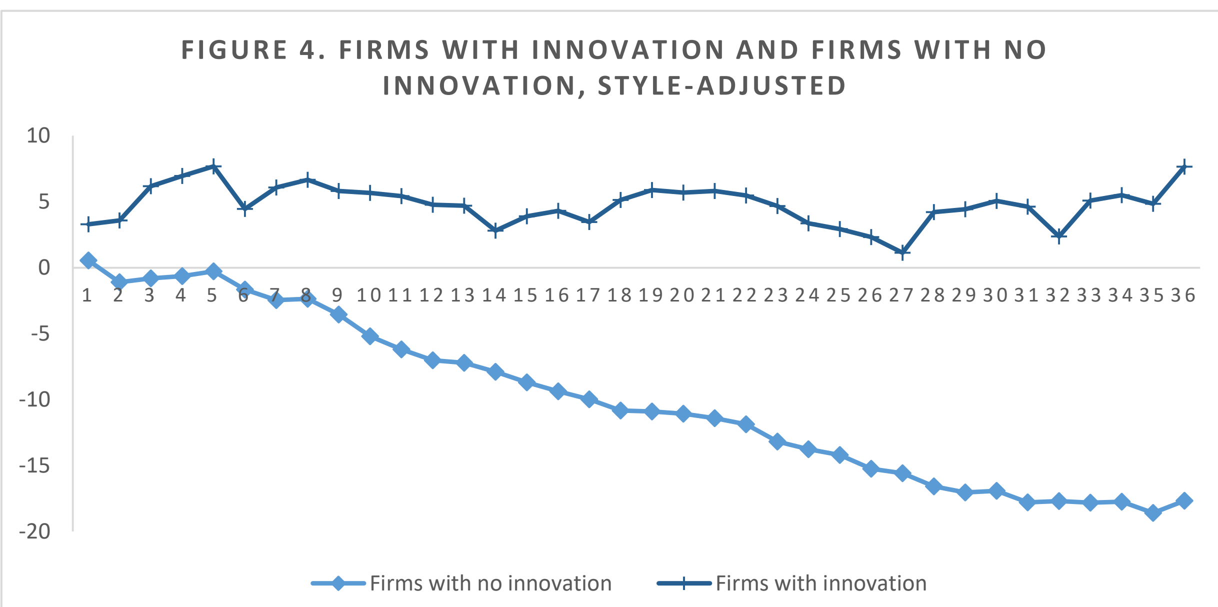

Figure 4. Cumulative buy-and-hold style-adjusted returns for firms with no innovation (2,949 firms) and firms with innovation (884 firms) from 1985 to 2007 with monthly rebalancing.

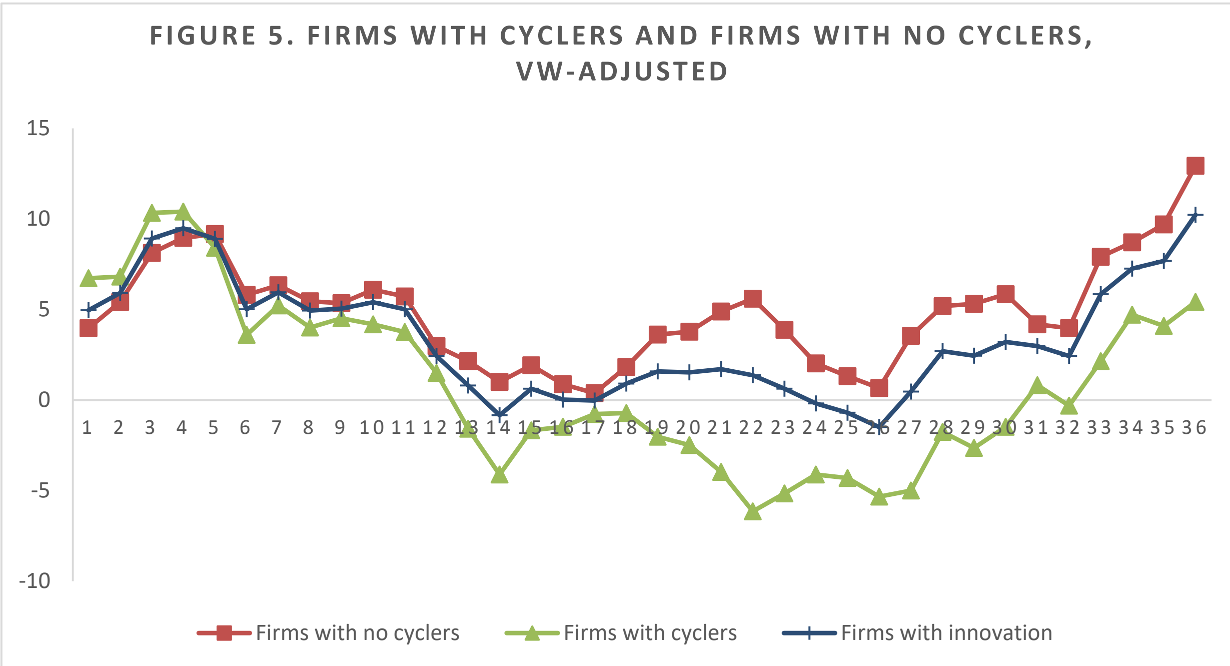

Figure 5. Cumulative buy-and-hold market-value-weighted-adjusted returns for firms with cyclers (318 firms) and firms with no cyclers (566 firms) from 1985 to 2007 with monthly rebalancing.

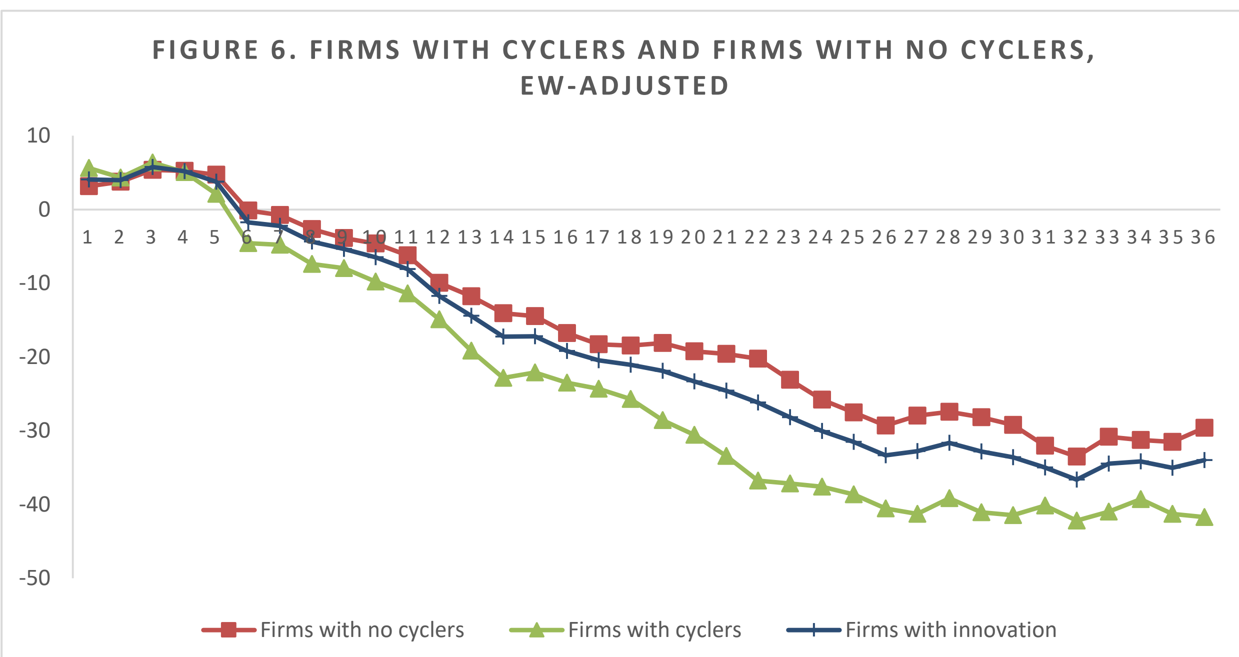

Figure 6. Cumulative buy-and-hold market-equal-weighted-adjusted returns for firms with cyclers (318 firms) and firms with no cyclers (566 firms) from 1985 to 2007 with monthly rebalancing.

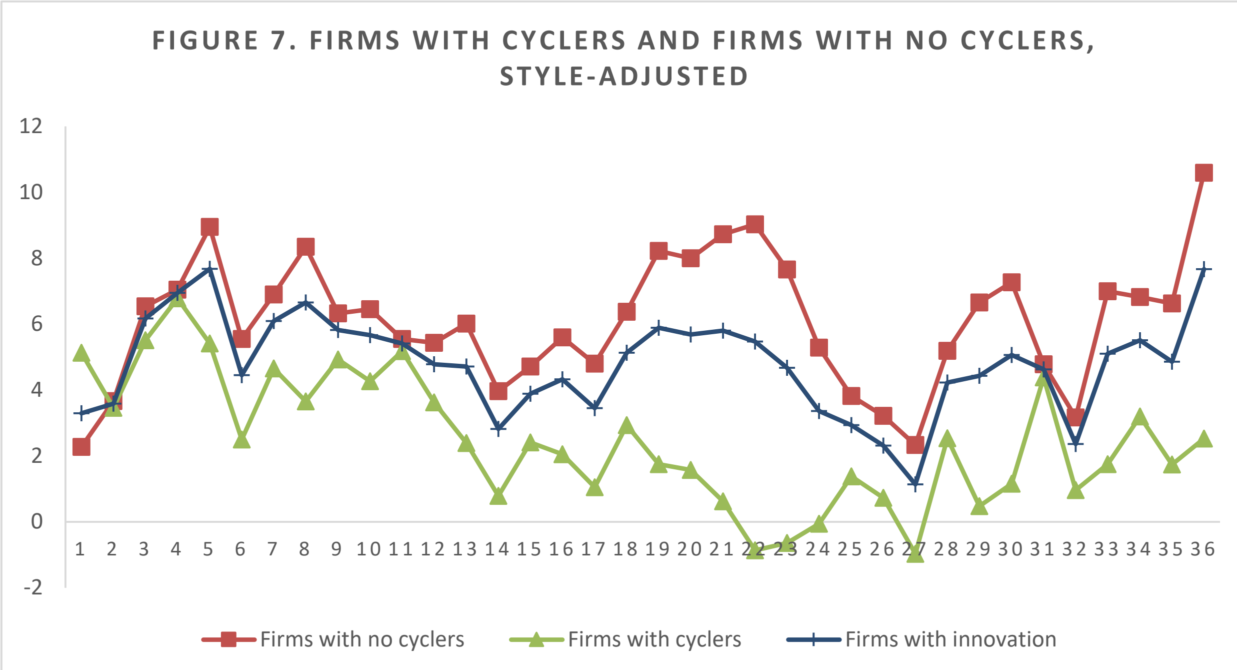

Figure 7. Cumulative buy-and-hold style-adjusted returns for firms with cyclers (318 firms) and firms with no cyclers (566 firms) from 1985 to 2007 with monthly rebalancing.

PART 3: INNOVATOR CEOS IN IPOS

I. INTRODUCTION

Innovation plays a critical role in promoting economic growth (Solow, 1957) and increases the probability of a firm's survival (Cefis and Marsili, 2006). Lin (2018a) and Islam and Zein (2018) both find that firms led by CEOs with innovative ability spur firm innovation. Lin (2018a) finds that around 10% of public firms have CEOs with innovative ability from 1992 to 2008.[73] For example, Mark Zuckerberg, the CEO of Facebook, filed his first patent on 2006. Bill Gates, the former CEO of Microsoft, has nine patents to his name. Steve Jobs, the former Apple CEO, even has 141 patents. The importance of innovation is also reflected on the initial public offering (IPO) market. Technology IPO firms have dominated he IPO market. Technology IPO have averaged 58% of total IPOs each year from 1980 to 2016. This leads to the question do tech-firms with innovator CEOs perform better during the IPO process than tech-firms with non-innovator CEOs. Do firms led by CEOs with innovative ability experience less underpricing and higher stock returns post-IPO period? Do firms led by CEOs with greater innovative ability spur more innovation after the IPO?

Over the past 40 years, many empirical studies document that IPOs are underpriced (i.e. the average first-day stock return is positive).[74] Specifically, Loughran and Ritter (2004) find the average first-day return for 8,254 IPOs approximates 18% between 1980 and 2016, suggesting

[73] Islam and Zein (2018) also find that one-in-five U.S. high-technology firms are led by CEOs with innovative ability.
[74] See, for example, Ibbotson (1975), Ritter (1984) and Loughran and Ritter (2004).

$155.16 billion left on the table.[75] Prior literature offers many explanations for this underpricing. For example, underwriter price support (Ruud, 1993), firms backed by venture capitals (Lee and Wahal, 2004), and investment bank reputation (Beatty and Ritter, 1986) may explain IPO underpricing. In addition to underpricing at issue, IPO firms experience long-run underperformance. Ritter (1991) finds that IPO firms have lower stock return for up to three years post IPO. Research finds that the reputation of underwriters and venture capitals (Brav and Gompers, 1997; Carter, Dark and Singh, 1998; and Dong, Michel and Pandes, 2011), accounting accruals in the IPO year (Teoh, Welch and Wong, 1998), and firm acquisition activities within a year of going public (Brau, Couch and Sutton, 2012) might explain the IPO long-run performance. Other research has found that the CEO can explain IPO underpricing and long-run underperformance. Fan, Wong and Zhang (2007) find that firms with CEOs who are former or current government bureaucrats have lower first-day stock return and underperform firms with non-politically-connected CEOs. Research also finds that IPOs with CEOs who are also the founders have larger underpricing (Certo, Covin, Daily and Dalton, 2001) and greater long-run stock returns (Gao and Jain, 2011). Given CEOs characteristics impact IPO outcomes and innovation matters (Solow, 1957), a natural question arises whether CEOs with innovative ability impact the firm's IPO. Bernstein (2015) and Aggarwal and Hsu (2012) both document that the quality and quantity of a firm's innovation decrease after going public, suggesting that private ownership promotes firm innovation and public ownership inhibits it. If a firm has a CEO who is interested in and has the ability to do the innovation, whether the firm's innovation will decrease

[75] The updated table can be found in the website. https://site.warrington.ufl.edu/ritter/files/2017/05/IPOs2016Underpricing.pdf

is unclear. In this paper, I examine the effects of a CEO with innovative ability on IPO underpricing, long-run performance and post-IPO firm innovation.

Using a sample of 717 IPOs from 1976 to 2010, I find that 12.1% of IPOs are led by CEOs who are also patent inventors (innovator CEOs). Examining the impact of innovator CEOs on IPO underpricing, I find that firms with innovators CEOs experience a lower first-day return (underpricing), suggesting that CEO's innovative ability can reduce the information asymmetry in the IPO market.

Next, I study the impact of innovator CEOs on IPO long-run performance and post-IPO innovation. Firms that are led by innovator CEOs experience higher IPO long-run performance than firms that are led by non-innovator CEOs. Specifically, firms with innovator CEOs have higher long-run performance measured as calendar-time returns using Fama French three-factor and five-factor models. I also find that firms with innovator CEOs have greater buy-and-hold benchmark-adjusted returns for the holding period three years post-IPO after controlling for other factors. I do not find that CEO's innovative ability is more important for high-tech firms for IPO long-run performance. However, CEO's innovative ability is more valuable for the IPO long-run performance if the CEO's patents and the firm's patents are in the same technological class. Examining the impact of innovator CEOs on post-IPO innovation, I find that Firms led by innovator CEOs have a greater post-IPO firm innovation up to four years after the IPO compared to firms led by non-innovator CEOs.

This paper contributes to the literature in several ways. First, this paper extends the literature on IPO underpricing and long-run performance. Specifically, this paper adds to the literature that studies the effects of the CEO on IPO performance, such as CEOs' political connection (Fan, Wong and Zhang, 2007), CEOs' stock option (Lowry and Murphy, 2007;

Chahine and Goergen, 2011) and founder CEO management (Gao and Jain, 2011). Second, this paper contributes to the growing literature on the role of the CEO's personality traits in the finance area. For example, Sunder, Sunder and Zhang (2017) study polite CEOs and firm innovation; and Malmendier and Tate (2008) investigate CEO overconfidence and firm acquisition activities. Third, this paper adds to the literature on firm innovation after an IPO.

II. HYPOTHESES DEVELOPMENT

Prior literature documents that information asymmetry is one explanation of IPO underpricing.[76] The information asymmetry is assumed to exist between informed and uninformed investors (Rock, 1986), between IPO firms and investors (Allen and Faulhaber, 1989; Chemmanur, 1993), or between investment banks and IPO firms (Baron, 1982). Specifically, Rock (1986) proposes that when the IPO market has informed and uninformed investors, informed investors will crowd out the uninformed investors for allocations of profitable issues. The IPO firm must underprice their IPO in order to guarantee that the uninformed investors purchase the issue. Allen and Faulhaber (1989) assume that the IPO firm best knows its prospects and find that it is optimal for the firm to signal the market by underpricing its issue.

Empirical studies find that reducing information asymmetry can decrease the underpricing. For example, if IPO firms have prestigious underwriters (Carter and Manaster, 1990) or are backed by venture capitalists (Barry, Muscarella, Peavy and Vetsuypens, 1990; and Megginson and Weiss, 1991), underpricing may be reduced. Also, the quality of the top management team (Cohen and Dean, 2005) and the reputation of a CEO (Chemmanur and Paeglis, 2005) serve as signals to the market and reduce IPO underpricing. Conti, Thursby and Thursby (2013) construct a theoretical model and empirically test it. They find that IPO firms use

[76] The other explanations of IPO underpricing include investment bankers caring about their reputation (Beatty and Ritter, 1986) and inducing asymmetrically informed investors to reveal information (Benveniste and Spindt, 1989), issuers' demand for ownership dispersion (Booth and Chua, 1996).

patents to signal their quality and value to investors, suggesting that the firm's patents can be a signal in the IPO market. Therefore, a CEO's innovative ability as a signal to the IPO market can reduce the information asymmetry and in turn, reduce underpricing. Further, Heeley, Matusik and Jain (2007) use patents to measure firm innovation and find that when firm innovation and value appropriation is transparent, innovation can reduce information asymmetry, and therefore, underpricing will be reduced.[77] However, when firm innovation and value appropriation is not transparent, innovation will increase information asymmetry, and therefore, underpricing will be greater. Therefore, when a CEO's innovative ability is easy to interpret by the IPO market, underpricing will be reduced, and when a CEO's innovative ability is difficult to interpret, underpricing will be greater.

Hypothesis 1a: Firms with innovator CEOs experience less IPO underpricing (lower first-day return) compared to firms with non-innovator CEOs.

Hypothesis 1b: Firms with innovator CEOs experience more IPO underpricing (higher first-day return) compared to firms with non-innovator CEOs.

Prior literature finds that innovation positively impacts a firm's market value (Pakes, 1985; Austin, 1993; Nicholas, 2008; Kogan, Papanikolaou, Seru and Stoffman, 2017). Specifically, Hall, Jaffe and Trajtenberg (2005) use patents and citations to measure innovation and find that innovation increases firm market value. Since the CEO is the most important person in a firm (Ireland and Hitt, 1999), and firms led by CEOs with innovative ability experience more innovation activities (Lin, 2018a; and Islam and Zein, 2018), a CEO's innovative ability

[77] They follow Cohen, Nelson and Walsh (2000) to identify whether an IPO was in a discrete or complex product industry. The industry with an ISIC code lower than 2900 is coded as discrete. The industry with an ISIC code of 2900 or higher is coded as complex. If a firm is in a discrete product industry, the link between firm innovation and value appropriation is transparent. If a firm is in a complex product industry, the link between firm innovation and value appropriation is not transparent.

should be important to a firm. Moreover, Lin (2018b) finds that the outflow of talent post-IPO can explain IPO long-run underperformance, suggesting the importance of employees' innovative ability to an IPO firm's long-run performance. Therefore, if a firm has a CEO with innovative ability, I expect the firm to have higher post-IPO stock returns compared to a firm led by CEOs with non-innovative ability. However, Lin (2018a) finds that firms led by innovator CEOs spend more money on research and development (R&D) but with lower efficiency, suggesting that innovator CEOs also result in overinvestment problems to the firm. This overinvestment is recognized by the stock market as there is a negative return when a new innovator CEO is hired (Lin, 2018a). Therefore, I expect firms led by innovator CEOs to have lower post-IPO long-run performance compared to firms led by non-innovator CEOs.

Hypothesis 2a: A CEO's innovative ability has a positive effect on an IPO firm's long-run performance.

Hypothesis 2b: A CEO's innovative ability has a negative effect on an IPO firm's long-run performance.

Bernstein (2015) and Aggarwal and Hsu (2012) both compare firms that go public with firms that withdrew from IPO filing and find that the firm's innovation decreases after going to public. Bernstein (2015) finds that the decreasing innovation after IPO is due to the outflow of patent inventors and the declined productivity of the remaining inventors. Since firms led by innovative CEOs have greater firm innovation compared to firms led by non-innovative CEOs (Lin, 2018a; and Islam and Zein, 2018), IPO firms led by innovative CEOs will not have a decline in firm innovation post-IPO.

Hypothesis 3: A CEO's innovative ability has a positive effect on a firm's post-IPO firm innovation.

III. SAMPLE CONSTRUCTION, VARIABLE MEASUREMENTS AND SUMMARY STATISTICS

SAMPLE CONSTRUCTION

Using Securities Data Corporation (SDC) New Issues Database, an initial sample of 9,173 IPOs from 1975 to 2016 is collected. CEO characteristics are collected from ExecuComp; however, ExecuComp covers only S&P 1500 firms, thus I exclude 8,196 IPO firms not in the ExecuComp database. Firm patent data is provided by Kogan, Papanikolaou, Seru and Stoffman (2017) from 1975 to 2010. Since the patent data ends in 2010, 69 IPOs are excluded from 2011 to 2015. Following IPO literature (e.g. Brau, Couch and Sutton, 2012), I remove 143 IPOs offered by financial firms (Standard Industrial Classification (SIC) codes between 6000 and 6999), foreign issuers, real estate investment trusts (REITs), unit offers, close-end funds, and limited partnerships. Firm financial information is obtained from Compustat. Stock returns are from the daily returns file of the Center for Research in Security Prices (CRSP). I further exclude 7 IPO firms with offer price under $5 per share and 41 IPO firms with missing financial information. The resulting sample consists of 717 IPO firms from 1976 to 2010.

VARIABLE MEASUREMENTS

This subsection describes the measurements of dependent variables, independent variables and control variables. The variable definitions are provided in the Appendix.

An innovator CEO is identified by merging the CEOs' names from the ExecuComp database and inventors' names from the Harvard Business School (HBS) patenting database constructed by Li, Lai, D'Amour, Doolin, Sun, Torvik, Amy and Fleming (2014).[78] The data of innovator CEO and the detailed process of identifying the innovator CEO is from Lin (2018a).[79] Innovator CEO is a dummy variable equal to one if the CEO has at least one patent during 1975 to 2010. In the sample, 87 firms are led by CEOs who are patent inventors, and 630 firms are led by CEOs who are not patent inventors.

Following Lin (2018a), I measure CEOs' innovative ability in six ways. The first measure (variable: CEO patent) counts the number of patents for which the CEO applied at the IPO year. The second measure (variable: CEO citation) counts the number of citations received by the patents applied at the IPO year. The third measure (variable: CEO avg. citation) is the ratio of CEO citation to CEO patent at the IPO year. The fourth measure (variable: CEO cumulative patent) counts the number of patents for which the CEO applied up to the IPO year. The fifth measure (variable: CEO cumulative citation) counts the number of citations received by the patents up to the IPO year. The sixth measure (variable: CEO cumulative avg. citation) is the ratio of CEO cumulative citation to CEO cumulative patent up to the IPO year. Since the quality

[78] HBS patenting database provides unique identifiers (variable: Invnum_N) for each patent's inventors from 1975 to 2010.

[79] The process of identifying the innovator CEO is as follow. First, I merge CEOs' name with patent inventors' name by their first, middle and last name. Second, in order to make sure that I accurately matched the inventor and the CEO, I hand collect the CEOs' biographical information based on the information from the company's website, Bloomberg CEO Biography, Wikipedia, Notable Names Data Base, news information, LinkedIn, and Forbes website.

of the patent is reflected on the patent citations, and these citations capture the technology and economic importance, I focus on the results using CEO avg. citation and Innovator CEO.[80]

IPO UNDERPRICING

IPO underpricing is measured as the first-day stock return of the IPO firm (also called initial retur). Following Lee, Lochhead, Ritter and Zhao (1996), the initial return equals the closing price one day after the offering date (SDC variable: PR1DAY) divided by offering price (SDC variable: P) minus one. If the closing price one day after the offering date is missing, the closing price two days after the offering date (SDC variable: PR2DAY) is used to calculate the initial return.

BUY-AND-HOLD ABNORMAL RETURNS

Following Ritter and Welch (2002), I measure buy-and-hold abnormal returns using stock monthly raw return minus the benchmark monthly raw return for the corresponding month starting the month of IPO to three years after an IPO. One month is considered as a successive 21-trading-day period, so the first month return does not include the first-day return of the IPO firm. The buy-and-hold abnormal return is calculated using three benchmarks: (1) CRSP value-weighted index, (2) CRSP equal-weighted index, and (3) style-matched firms which are a portfolio of non-IPO firms matched to IPO firms based on size and market-to-book. The style-matched firms are constructed following Lyon, Barber and Tsai (1999) and Ritter and Welch

[80] Results using the other measures are quantitatively similar to innovator CEO and available upon request.

(2002). First, the matching non-IPO firms are required to be listed on CRSP for at least five years with no equity issuances within last five years. Second, the matching non-IPO firms are required to have a market capitalization equal to ±30% of the IPO firms' market capitalization. Third, the matched non-IPO firm is the one with the closest market-to-book ratio to the IPO firm. If the matched firm delists before three years post-IPO, I splice in the next closest market-to-book matching firm.

Equation (1) expresses the calculation of the buy-and-hold abnormal stock return:

$$AR_{0,3}^{i} = \prod_{t=1}^{36}(1 + r_t^i) - \prod_{t=1}^{36}(1 + r_t^b), \qquad (1)$$

where $AR_{0,3}^{i}$ is the buy-and-hold benchmark-adjusted return for firm i for months 1-36 after the IPO, r_t^i is stock raw return for the firm i in month t after the IPO, and r_t^b is the benchmark return in month t. If an IPO firm is delisted before three years post-IPO, I follow Ritter (1991) and Loughran and Ritter (1995) and use their truncated abnormal return at the delisting date as the buy-and-hold abnormal return.

FIRM INNOVATION

The data for firm innovation is from Kogan et al. (2017), including all utility patents issued by U.S. Patent and Trademark Office (USPTO).[81] The patent database provides patent

[81] According to U.S. Patent and Trademark Office (USPTO), "a utility patent protects the way an article is used and works". Specifically, the utility patent is a trademark protection that makes sure a person has full control over his or her invention.

assignee's CRSP unique identifier (PERMNO), the application and grant date of the application, the citation received by the patent, the patent class, and the estimated market value of the patent.

Firm innovation is measured five ways. The first measure (variable: Firm patent) is the count of the number of patents for which the firm applied in a given year. The second measure (variable: Firm citation) is the count of the number of citations received by the patents for which the firm applied in a given year, capturing the importance of the patents' technology. The third measure (variable: Firm avg. citation) is the ratio of firm citation over firm patent in a given year. The fourth measure (variable: Citation-weighted firm innovation) adjust for the citation truncation lags (Hall, Jaffe, Trajtenberg, 2005). Following Kogan et al. (2017), I calculate the fourth measure by first constructing $\omega_{i,t}$, which is the sum of the weight of citations for each patent for firm i in time t:

$$\omega_{i,t} = \sum_{j \in P_{i,t}} \left(1 + \frac{C_j}{\overline{C_j}}\right), \tag{2}$$

where C_j is the number of citation received by patent j, $\overline{C_j}$ is the average number of citations received by the patents that were granted in the same year as patent j, and $P_{i,t}$ is the set of patents applied for firm i in year t. Then, $\omega_{i,t}$ is scaled by book assets due to the fact that $\omega_{i,t}$ is increasing in firm size (Kogan et al., 2017),

$$W_{i,t}^{cw} = \frac{\omega_{i,t}}{B_{i,t}}, \tag{3}$$

where $B_{i,t}$ is the book assets of firm i in year t, and $W_{i,t}^{cw}$ is the citation-weighted innovation for firm i firm in time t. To further capture the value added of patents to the firm, I construct a fifth measure (variable: Market-value firm innovation) using the dollar value of the patent calculated by Kogan at el. (2017) based on the stock return response to news about the patents:

$$\theta_{i,t} = \sum_{j \in P_{i,t}} x_j \ , \tag{4}$$

where $\theta_{i,t}$ is the total dollar value of the patents applied by the firm i in time t, and x_j is the dollar value of patent j. Market-value firm innovation is calculated by using $\theta_{i,t}$ divided by book assets:

$$W_{i,t}^{mv} = \frac{\theta_{i,t}}{B_{i,t}} \ , \tag{5}$$

where $W_{i,t}^{mv}$ is the market-value firm innovation, and $B_{i,t}$ is book assets of firm i in year t.

CONTROL VARIABLES

I control for firm characteristics and CEO characteristics that may affect IPO long-run performance, underpricing, and post-IPO firm innovation. Following the IPO literature, firm characteristics include venture capital backing defined as a dummy variable equal to one if the firm is VC-backed, and zero otherwise, the rankings of lead underwriter obtained from Loughran and Ritter (2004), Tobin's Q defined as the natural logarithm of market value of assets over the book value of assets, firm age at the IPO year obtained from Loughran and Ritter (2004), and the IPO proceeds raised at the IPO. [82] I also control for firm innovation using the number of patents

[82] The rank of leading underwriter is from 0 to 9, and 9 stands for the highest rank.

the firm applied during the stock return period. CEO characteristics include CEO tenure defined as the number of months a CEO is in the firm and CEO age in years.

SUMMARY STATISTICS

Table 1 presents the distribution of IPO firms with innovator CEOs and non-innovator CEOs by year and by industry. Panel A shows the year distribution of IPOs with innovator CEOs in the sample from 1976 to 2010 by year. In the sample, 87 IPOs are led by innovator CEOs and 630 IPOs are led by non-innovator CEOs. On average, there are 12.1% IPO firms with innovator CEOs in the sample. The percentage of IPOs with innovator CEOs is highest in 1990 (31.6%). Panel B displays the percentage of IPO firms with innovator CEOs by Fama and French 12 industry groups excluding financial firms and utility firms.[83] The consumer durables industry has the highest percentage of innovator CEOs (25.0%), the health industry is the second highest industry (22.0%), and the business equipment industry has the highest number of innovator CEOs (36). The manufacturing industry and the telephone and television transmission industry have no IPO firms with innovator CEOs. Panel C tabulates the distribution of innovator CEOs by high-tech and non-high-tech industries based on the categorizations in Loughran and Ritter (2004)[84]. In the high-tech industry, 18.2% of IPO firms have innovator CEOs, which is higher than 9.6% in the non-high-tech industry. However, the number of IPO firms with innovator

[83] The categorization of Fama and French indsutries are in Fama's website. http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html#Research

[84] In Loughran and Ritter (2004) appendix D, high-tech stocks are defined as those in SIC codes 3571, 3572, 3575, 3577, 3578 (computer hardware), 3661, 3663, 3669 (communications equipment), 3671,3672, 3674, 3675, 3677, 3678, 3679 (electronics), 3812 (navigation equipment), 3823,3825,3826,3827,3829 (measuring and controlling devices), 3841, 3845 (medical instruments), 4812, 4813 (telephone equipment), 4899 (communications services), and 7371, 7372, 7373, 7374, 7375, 7378, and 7379 (software).

CEOs is higher in non-high-tech industry (49) than in the high-tech industry (38), suggesting that innovator CEOs are important for both high-tech and non-high-tech industries.

Table 2 presents the summary statistics of CEO characteristics and firm characteristics for the full sample, IPOs with non-innovator CEOs and IPOs with innovator CEOs. The table reports the mean, median, and standard deviation for the variables in each of the samples. T-tests are also conducted to test for differences between the means for IPO firms with innovator CEOs and IPO firms with non-innovator CEOs. Examining innovator CEOs' innovative abilities, I find that on average, innovator CEOs have 0.58 patents, 32.59 citations, and 16.46 citations per patent during the IPO year, and cumulative 6.76 patents, 280.20 citations, and 38.21 citations per patent up to the IPO year. I also find that the tenure for innovator CEOs are 76 months on average, which is significantly higher than the 61 months tenure of non-innovator CEOs. On average, the age of innovator CEO is 48 years, and the age of non-innovator CEOs is 49 years, and the difference is not significant.

Comparing the firm characteristics between IPOs with innovator CEOs and IPOs with non-innovator CEOs, I find that although IPO firms with innovator CEOs and IPO firms with non-innovator CEOs have no significant difference in firm patents at the IPO year, IPO firms with innovator CEOs have more citations and average citations per patent and invest more in R&D projects than IPO firm with non-innovator CEOs. The results suggest that the quality of patents in IPO firms with innovator CEOs is higher than that of IPO firms with non-innovator CEOs. I also find that IPO firms with innovator CEOs have significantly more venture capital backing and younger than IPO firms with non-innovator CEOs. In the full sample, on average, the initial return is 25.54%, Tobin's Q is 3.99, the underwriter rank is 7.47, and the proceeds raised at the IPO firms is 109.20 million. There are no significant differences in these variables between IPO firms with innovator CEOs and IPO firms with non-innovator CEOs.

IV. IPO UNDERPRICING

This section presents the effects of innovator CEOs on IPO underpricing. The regression model follows:

$$\begin{aligned}
&\text{Initial return}_i \\
&= \alpha_1 + \beta_1 Innovator\ CEO_i + \beta_2 VC_i + \beta_3 \text{Ln(Firm age)}_i + \beta_4 \text{Tobin's Q}_i \\
&+ \beta_5 \text{UW rank}_i + \beta_6 Ln(Proceeds)_i + \beta_7 Bubble\ year_i + \beta_8 Hi_tech_i + \beta_9 Firm\ patent_i \\
&+ \beta_{10} CEO\ age_i + \beta_{11} Log\ (1 + tenure)_i + \gamma_k + \delta_t \\
&+ \varepsilon_{1i}, \qquad (6)
\end{aligned}$$

where Initial return_i is the first-day stock return of firm i, $Firm\ patent_i$ is the number of patents the CEO applied at the IPO year and all the other variables are as previously defined. Table 3 shows the results of equation (6). I find that firms with innovator CEOs have lower first-day return, indicating that firms with innovator CEOs experience lower IPO underpricing than firms with non-innovator CEOs. The results suggest that CEOs' innovative ability serve as a signal of the quality of the firm and can reduce underpricing, which is consistent with Hypothesis (1a). Examining the control variables, I find that firms with greater growth opportunity and firms in the tech-bubble years have higher IPO underpricing, which is consistent with Ljungqvist and Wilhelm (2003).I also find that firms in the high-tech industry experience lower IPO underpricing.

V. IPO LONG-RUN PERFORMANCE

This section presents the univariate results for buy-and-hold abnormal returns, the methodology and results of calendar-time factor model results, and the cross-sectional regression analysis controlling for other factors that may affect IPO long-run performance between IPO firms with innovator CEOs and IPO firms with non-innovator CEOs. Since buy-and-hold abnormal returns can better represent a long-term investor's experience but pose overlap problems (Brav, 2000), and calendar-time factor models can mitigate this problem as recommended by the researchers (Lyon, Barber and Tsai, 1999), I follow the IPO long-run performance literature and use both methods.

UNIVARIATE RESULTS

Table 4 presents the buy-and-hold abnormal returns for the full sample, IPO firms with non-innovator CEOs, and IPO firms with innovator CEOs for up to five years after the IPO from 1976 to 2010. The average market-value-weighted-adjusted and style-adjusted returns are significantly positive for the holding periods up to five years post IPOs for the full sample, IPO firms with non-innovator CEOs, and IPO firms with innovator CEOs. The results are surprising since prior IPO literature (e.g. Ritter, 1991) documents a significant negative buy-and-hold abnormal return post-IPO. The positive abnormal returns in my sample are possibly due to the IPOs from the ExecuComp database covering the S&P 1500 firms. Comparing the buy-and-hold abnormal returns between IPO firms with innovator CEOs and IPO firms with non-innovator

CEOs, I find that the abnormal returns are higher for IPO firms with innovator CEOs than that of IPO firms with non-innovator CEOs, but are not significant for the holding period up to four years post IPOs. For the five year holding period, IPO firms with innovator CEOs significantly outperform IPO firms with non-innovator CEOs. The mean market-value-weighted-adjusted (style-adjusted) return for five years post IPO is 207.51% (252.68%) for IPO firms with innovator CEOs and 112.25% (119.70%) for IPO firms with non-innovator CEOs, and the difference test is significant at 10% (5%) level.

CALENDAR-TIME FACTOR MODEL REGRESSION

In the calendar time approach, I calculate the time series of monthly portfolio returns for IPO firms with innovator CEOs and IPO firms with non-innovator CEOs and estimate the three-factor Fama and French model (1993) and five-factor Fama and French (2014). I estimate the five-factor model as follows:

$$R_{pt} - r_{ft} = a + b\left(R_{mt} - r_{ft}\right) + sSMB_t + hHML_t + rRMW_t + cCMA_t + e_t, \tag{7}$$

where R_{pt} is the monthly return for an equal-weighted calendar-time portfolio of IPOs in month t, R_{mt} is the monthly return on the CRSP value-weighted market index in month t, r_{ft} is the monthly return on the three-month Treasury bills in month t, $\left(R_{mt} - r_{ft}\right)$ is the market risk premium MRP, SMB_t is the monthly return on a value-weighted portfolio of small firms minus the return on a value-weighted portfolio of large firms in month t, HML_t is the monthly return on a value-weighted portfolio of high book-to-market stocks minus the return on a value-weighted portfolio of low book-to-market stocks in month t, $rRMW_t$ is the monthly return on a value-weighted portfolio of high operating profitability stocks minus the return on a value-weighted portfolio of low operating profitability stocks in month t, and $cCMA_t$ is the monthly return on a value-weighted portfolio of conservative investment stocks minus the return on a value-weight portfolio of aggressive investment stocks. The intercept (a) represents the abnormal performance.

Since Brav, Geczy and Gompers (2000) document that the misspecification problem of the three-factor model for predicting returns on small firms with high growth rate can lead to the findings of IPO underperformance, I follow Loughran and Ritter (2000) to address this concern. Specifically, I use the Fama French three-factor model after purging the factors of new issues.[85] I estimate the three-factor model as follows:

$$R_{pt} - r_{ft} = a + b\left(R_{mt} - r_{ft}\right) + sSMB_t + hHML_t + e_t, \tag{8}$$

where SMB_t is the monthly return on a value-weighted portfolio of small firms minus the return on a value-weighted portfolio of large firms in month t purged of IPO and SEO firms, and HML_t is the monthly return on a value-weighted portfolio of high book-to-market firms minus the return on a value-weighted portfolio of low book-to-market stocks in month t purged of IPO and SEO firms. Again, the intercept (a) represents the abnormal performance.

Table 5 presents the results of Fama French three-factor model, five-factor model, and Fama French three-factor model after purging the IPO and SEO firms for the full sample, IPO firms with innovator CEOs and IPO firms with non-innovator CEOs for the period of 0-36 months after an IPO. For the full sample, IPO firms have a significant positive monthly abnormal return of 0.90% in the Fama French three-factor model and 0.99% in the Fama French five-factor

[85] The three-factor after purging the IPO and SEO firms is from Ritter's website for the period of 1973 to 2003. https://site.warrington.ufl.edu/ritter/ipo-data/

model, while the magnitude and the significance of the abnormal returns decreases in the Fama French three factor model after purging IPO and SEO firms. Comparing the abnormal return for firms with innovator CEOs and firms with non-innovator CEOs, I find that firms with non-innovator CEOs have no abnormal return in both Fama French three-factor model and Fama French five-factor model, while firms with innovator CEOs have significant positive returns in Fama French three-factor model (1.502%), Fama French five-factor model (1.775%), and Fama French three-factor model after purging IPO and SEO firms (1.192%). The results support Hypothesis (2a) that a CEO's innovative ability has a positive effect on an IPO firm's long-run performance.

CROSS-SECTIONAL REGRESSION ANALYSIS

In the cross-sectional regression, I control for other factors that may affect the buy-and-hold returns of the IPO firms in order to investigate the effect of the innovative ability of the innovator CEOs on firm long-run performance. Specifically, I conduct the following multivariate cross-sectional regression:

$$AR_{0,3}^{i} = \alpha_1 + \beta_1 CEO\ avg.citation_i + \beta_2 VC_i + \beta_3 \text{Ln(Firm age)}_i + \beta_4 \text{Initial return}_i$$
$$+ \beta_5 \text{Tobin's Q}_i + \beta_6 \text{UW rank}_i + \beta_7 Ln(Proceeds)_i + \beta_8 Bubble\ year_i$$
$$+ \beta_9 Hi\_tech_i + \beta_{10} CEO\ age_i + \beta_{11} Log\ (1 + tenure)_i$$
$$+ \beta_{12} Firm\ innovation03_i + \gamma_k + \delta_t + \varepsilon_{1i}, \qquad (9)$$

where $AR_{0,3}^{i}$ is the buy-and-hold benchmark-adjusted return for firm i from the IPO year to three years after the IPO, $CEO\ avg.citation_i$ is the average citations per patent for the CEO in firm i at the IPO year, $Bubble\ year_i$ is a dummy variable equal to one if the IPO year of firm i is in

1999 or 2000 and zero otherwise, Hi_tech_i is a dummy variable equal to one if the firm is in the high-tech industries based on Loughran and Ritter (2004)'s categorizations and zero otherwise, and $Firm\ innovation03_i$ is the average citations per patent for firm i during the three years after the IPO year. Other variables are as previously defined. I also control for industry fixed effects (γ_k) and year fixed effects (δ_t). I expect β_1 to be positively significant, suggesting that CEOs' innovative ability has a positive effect on IPO long-run performance.

Table 6 column (1) to (3) presents the results of the effects of innovator CEOs on IPO long-run performance. I find that the coefficient of $CEO\ avg.citation_i$ is positive and significant in all the three regressions, suggesting that CEOs' innovative ability positively impacts the three year buy-and-hold abnormal returns. Again, the results support Hypothesis (2a).

Since innovation is more important for high-tech firms (Brown, Fazzari and Peterson, 2009), I expect high-tech industries would benefit more from CEOs' innovative ability. However, if innovator CEOs pursue their own interests and invest more on R&D projects, innovator CEOs might bring over investment problems to the firm (Lin, 2018a). In order to study the impact of CEOs' innovative ability on high-tech industries, I include the interaction of $CEO\ avg.citation_i$ and Hi_tech_i as an additional independent variable in equation (9). Table 6 column (4) to (6) shows the results. I find that the coefficients of the interaction term between $CEO\ avg.citation_i$ and Hi_tech_i are negatively significant, suggesting that in high-tech industries, CEOs' innovative ability hurts the IPO long-run performance.[86] The results are

[86] The negative effects of CEOs' innovative ability disappears

unexpected since the negative impacts of CEOs' innovative ability in high-tech industry contradicts the traditional point of view that innovation is important for high-tech industries.

Further, I investigate the usefulness of CEOs' innovative ability on IPO long-run performance. When CEO's expertise is in the same area of the firm's main business, I define CEOs' innovative ability as useful for the firm. I include two additional independent variables in equation (9), $Same\ class_i$ defined as a dummy variable equal to one if the CEOs' patents technological class is the same as the firms' patents technological class, and the interaction of $CEO\ avg.citation_i$ and $Same\ class_i$. Table 6 column (6) to (9) presents the results. The interaction term between $CEO\ avg.citation_i$ and $Same\ class_i$ is positively significant, suggesting that when CEOs' innovative ability is useful and beneficial to the firm, CEOs' innovative ability positively impact IPO long-run performance. I also find that VC involvement is positively and significantly related to the buy-and-hold benchmark-adjusted returns, consistent with Brav and Gompers (1997). Further, firm proceeds raised at IPO and growth opportunities are negatively related to the IPO long-run performance, while firm innovation over the three year holding period is positively related to the IPO long-run performance.

Next, I study why CEOs' innovative ability hurts IPO long-run performance for firms in high-tech industries. If the negative impacts of CEOs' innovative ability on IPO long-run performance in the high-tech industry are caused by innovator CEOs' overinvestment problem, I expect innovator CEOs in the high-tech industry to hold less cash and invest more in R&D projects.[87] I estimate the regression as below:

[87] According to agency theory (Jensen and Meckling, 1976), holding more cash allows the CEOs to invest in projects that benefits the CEO but jeopardize shareholders' value. For innovator CEOs, holding more cash allows them to invest more in innovative projects leading to the overinvestment problem in the firm.

$$(Cash/TA)_{i,t+3}\ or\ (R\&D/TA)_{i,t+3}$$
$$= \alpha_1 + \beta_1 Innovator\ CEO_i + \beta_2 Innovator\ CEO * Hi\_tech_i + \beta_3 Hi\_tech_i$$
$$+ \beta_4 VC_i + \beta_5 \text{Ln(Firm age)}_i + \beta_6 \text{Tobin's Q}_i$$
$$+ \beta_7 \text{UW rank}_i + \beta_8 Ln(Proceeds)_i + \beta_9 Sales_i + \beta_{10} ROA_i + \beta_{11} CEO\ age_i$$
$$+ \beta_{12} Log\ (1 + tenure)_i + \gamma_k + \delta_t + \varepsilon_{1i}, \qquad (10)$$

where the $(Cash/TA)_{i,t+3}$ is the cash holdings divided by total assets for firm i in the three years after the IPO, $(R\&D/TA)_{i,t+3}$ is the research and development expenditures divided by total assets for firm i in three years after the IPO, $Sales_i$ is firm i sales at the IPO year, and ROA_i is the ratio of net income to total assets for firm i at the IPO year. Other variables are as previously defined.

Table 7 presents the results of equation (10). Comparing IPO firms with innovator CEOs and IPO firms with non-innovator CEOs, I find that IPO firms with innovator CEOs do not hold more cash three years after the IPO (in Column (1)), and that IPO firms with innovator CEOs spend more on R&D projects (in Column (3)). However, the interaction term between $Innovator\ CEO_i$ and Hi_tech_i is negatively significantly related to $(Cash/TA)_{i,t+3}$ (in Column (3)) and $(R\&D/TA)_{i,t+3}$ (in Column (5)), suggesting that innovator CEOs in the high-tech firms hold less cash after the IPO but do not spend the cash on R&D projects. The results suggest that the negative impacts of CEOs' innovative ability on IPO long-run performance in the high-tech industry is not due to overinvestment by innovator CEOs.

VI. POST-IPO FIRM INNOVATION

This section examines the effects of innovator CEOs on post-IPO firm innovation. Since highly innovative firms are more likely to hire innovator CEOs, the regression model has endogeneity problem. To deal with this problem, I use two-stage least square (2SLS). A selection of the instrumental variable (IV) is required to conduct the 2SLS regression. Following Lin (2018a), I use CEO coauthors' ability as an IV since people with greater innovative ability are more likely to work with people with greater innovative ability. Therefore, CEO coauthors' innovative ability can impact firm innovation only through CEOs' innovative ability. I estimate the follow regression as the first-stage:

$$\begin{aligned} Innovator\ CEO_i &= \alpha_1 + \beta_1 CEO\ coauthors'\ ability_i + \beta_2 VC_i + \beta_3 \text{Ln(Firm age)}_i \\ &+ \beta_4 \text{Tobin's Q}_i + \beta_5 \text{UW rank}_i + \beta_6 Ln(Proceeds)_i + \beta_7 Bubble\ year_i \\ &+ \beta_8 Hi\_tech_i + \beta_9 CEO\ age_i + \beta_{10} Log\ (1 + tenure)_i + \gamma_k + \delta_t \\ &+ \varepsilon_i\ , \qquad (11) \end{aligned}$$

where $CEO\ coauthors'\ ability_i$ is defined as firm i CEOs' coauthors average citations that the coauthors have shared with other authors to average patents that the coauthors have shared with other authors, and all the other variables are previously defined. This sample only includes CEOs with single authors. Examining the first-stage results, I find that $CEO\ coauthors'\ ability_i$ is positively related to $Innovator\ CEO_i$, which is consistent with my prediction. The IV also pass the overidentification test and underidentification test. Therefore, $CEO\ coauthors'\ ability_i$ is a valid IV.

The second-stage regression estimates the impacts of the predicted value of innovator CEO on post-IPO firm innovation:

$$
\begin{aligned}
Firm\ innovation_{i,t} \\
&= \alpha_1 + \beta_1 \widehat{Innovator\ CEO}_i + \beta_2 VC_i + \beta_3 \text{Ln(Firm age)}_i + \beta_4 \text{Tobin's Q}_i \\
&+ \beta_5 \text{UW rank}_i + \beta_6 Ln(Proceeds)_i + \beta_7 Bubble\ year_i + \beta_8 Hi\_tech_i \\
&+ \beta_9 CEO\ age_i + \beta_{10} Log\ (1 + tenure)_i + \gamma_k + \delta_t \\
&+ \varepsilon_i\ , \qquad (12)
\end{aligned}
$$

where $\widehat{Innovator\ CEO}_i$ is a predicted value from equation (11), $Firm\ innovation_{i,t}$ as defined early is measured in five ways: firm patent, firm citation, firm averaged citation per patent, citation-weighted firm innovation and market-value firm innovation. Firm innovation is measured in both two and three year periods post-IPO. All other variables are as previously defined.

Table 8 reports the second-stage regression results. I find that IPO firms with innovator CEOs experience greater firm innovation two years after the IPO compared to firms with non-innovator CEOs. These results are consistent with Hypothesis 3. The impacts of innovator CEOs on firm innovation decreases three years after the IPO since innovator CEOs impact firm innovation only when firm innovation is measure by firm average citation per patent and citation-weighted firm innovation, and the magnitude and significance of the coefficients of innovator CEOs decrease slightly. The effects of innovation CEOs on firm innovation disappear five years after the IPO.[88] The control variables are consistent with the literature. IPO firms with venture capital backing experience greater post-IPO firm innovation, consistent with Chemmanur, Loutskina and Tian (2014). I also find that younger firms, firms with greater growth opportunity, bigger firms, firms with reputable underwriter, and high-tech firms experience greater post-IPO firm innovation. Firm innovation before the IPO also positively and significantly impact post-IPO firm innovation.

[88] The results for five years after the IPO do not tabulated on Table 8 but are available upon request.

VII. ROBUSTNESS

I first employ a propensity score matching procedure following Rosenbaum and Rubin (1983) to reexamine the effects of innovator CEOs on IPO underpricing and post-IPO firm innovation. Propensity score matching allows me to construct a group of control firms that are led by non-innovator CEOs based on CEO and firm characteristics. Therefore, the differences on firm innovation between firms with innovator CEOs and the control firms with non-innovator CEOs should be only due to the innovator CEO. There are two steps to implement this methodology. First, I conduct the logit regression to calculate the probability (propensity score). I construct a nearest-neighbor matched sample for innovator CEOs using all the control variables in equation (10) or equation (12) and choose the firms with non-innovator CEOs with propensity scores closest to those of each innovator CEO. Second, I run ordinary least square (OLS) regression controlling for CEO and firm characteristics, year fixed effects, and industry fixed effects.

Table 9 reports the propensity score matching results. Again, I find that firms with innovator CEOs experience less IPO underpricing (in Column (1) and (2)), which is consistent with Hypothesis (1a). I also find that firms with innovator CEOs have more firm innovation three years after the IPO (in Column (3) to (10)), which is consistent with Hypothesis (3).

I also define the innovator CEO in two different ways. First, a CEO is defined as an innovator CEO if the CEO has at least one patent application before becoming the CEO of the firm. I find 29 CEOs who are innovator CEOs. Second, a CEO is defined as an innovator CEO if the CEO has at least one patent application before the IPO year. According to this definition, there are 61 CEOs who are innovator CEOs. The results of using those two different definitions of innovator CEOs are generally consistent with the previous results presented in this paper. The only difference is that when the innovator CEO is defined by the second alternative definition, the first-day return of firms with innovator CEOs is not significantly different from that of firms with non-innovator CEOs. This could be because CEOs use power to enforce their name on patents and the market only values the CEO's patents before becoming the CEO, which reflect the true innovative ability of the CEO.[89]

[89] I also define innovator CEO if the CEO has at least one patent application between the year of becoming the CEO and IPO year. I find 32 innovator CEOs according to this definition. The first-day return of firms with innovator CEOs is not significantly different from that of firms with non-innovator CEOs. Again, this results suggest that the stock market does not value the CEO's patent after becoming the CEO.

VIII. CONCLUSION

This paper studies the effects of innovator CEOs on IPO underpricing, long-run performance and post-IPO firm innovation. Specifically, I find that firms that are led by innovator CEOs experience lower IPO first-day stock return (lower underpricing) compared to firms that are led by non-innovator CEOs, suggesting that CEOs' innovative ability can reduce information asymmetry in the IPO market. I also find that firms with innovator CEOs have greater IPO long-run performance in both the calendar-time factor model using Fama French three-factor and five-factor models, and the cross-sectional regressions using buy-and-hold benchmark-adjusted return. Bernstein (2015) finds that firm innovation decreases after the IPO. I examine if innovator CEOs can alter the outcome. I find that innovator CEOs experience greater post-IPO firm innovation for up to four years after the IPO, suggesting that innovator CEOs can alleviate the decreased firm innovation after the IPO.

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APPENDIX

APPENDIX 1: Year and Industry Distribut

Table 1
Year and Industry Distribution

This table provides the breakdown of the number of non-innovator CEOs, number of innovator CEOs, and the percentage of innovator CEOs in the sample by year (Panel A) and by industry excluding financial firms and utilities (Panel B and C). The sample of CEOs is from ExecuComp for the period of 1976-2010.

Panel A: Distribution by Year

Year	Non-Innovator CEOs (#)	Innovator CEOs (#)	Innovator CEOs (%)
1976	1	0	0.0%
1980	1	0	0.0%
1982	4	0	0.0%
1983	13	3	18.8%
1984	5	1	16.7%
1985	6	1	14.3%
1986	25	4	13.8%
1987	28	5	15.2%
1988	11	3	21.4%
1989	13	0	0.0%
1990	13	6	31.6%
1991	43	6	12.2%
1992	48	9	15.8%
1993	54	3	5.3%
1994	31	8	20.5%
1995	35	6	14.6%
1996	49	6	10.9%
1997	35	5	12.5%
1998	26	2	7.1%
1999	40	1	2.4%
2000	19	5	20.8%
2001	6	1	14.3%
2002	8	2	20.0%
2003	7	0	0.0%
2004	18	4	18.2%
2005	23	2	8.0%
2006	21	0	0.0%
2007	23	2	8.0%
2008	2	0	0.0%
2009	13	2	13.3%
2010	9	0	0.0%
Total	630	87	12.1%

Panel B: Distribution by Fama-French 12 Industry Groups

Industry	Non-Innovator CEOs (#)	Innovator CEOs (#)	Innovator CEOs (%)
Consumer NonDurables	30	3	9.1%
Consumer Durables	3	1	25.0%
Manufacturing	53	8	13.1%
Enrgy	24	0	0.0%
Chems	13	1	7.1%
Business Equipment	164	36	18.0%
Telephone and Television Transmission	13	0	0.0%
Shops	98	5	4.9%
Health	71	20	22.0%
Other	161	13	7.5%
Total	630	87	12.1%

Panel C: Distribution by High-tech industry following Loughran and Ritter (2004)

Industry	Non-Innovator CEOs (#)	Innovator CEOs (#)	Innovator CEOs (%)
High-tech	171	38	18.2%
Non-high-tech	459	49	9.6%
Total	630	87	12.1%

APPENDIX 2: Summary Statistics

Table 2

Summary Statistics

This table presents summary statistics of the variables used in this study at the IPO year. T-tests are conducted to test for differences between the means for firms with innovator CEOs and non-innovator CEOs. Variable definitions are provided in the Appendix. *, ** and *** denote significance at the 10%, 5%, and 1% level, respectively.

	Full sample				Non-Innovator CEOs				Innovator CEOs			
Variable	N	Mean	Median	Std. Dev.	N	Mean	Median	Std. Dev.	N	Mean	Median	Std. Dev.
CEO characteristic												
CEO patent	717	0.07	0.00	0.49	630	0.00	0.00	0	87	0.58***	0.00	1.32
CEO citation	717	3.95	0.00	59.18	630	0.00	0.00	0	87	32.59***	0.00	167.96
CEO avg. citation	717	2.00	0.00	29.55	630	0.00	0.00	0	87	16.46***	0.00	83.83
CEO cumulative patent	717	0.82	0.00	5.63	630	0.00	0.00	0	87	6.76***	2.00	14.96
CEO cumulative citation	717	34.00	0.00	212.12	630	0.00	0.00	0	87	280.20***	51.00	552.11
CEO avg. cumulative citation	717	4.64	0.00	31.17	630	0.00	0.00	0	87	38.21***	15.50	82.40
Tenure (months)	659	62.48	48.00	67.48	580	60.58	36.00	68.34	79	76.41*	72.00	59.39
CEO age (years)	710	48.66	48.00	7.76	624	48.77	48.00	7.76	86	47.83	47.00	7.79
Firm characteristic												
Innovator CEO	717	0.12	0.00	0.33	630	0.00	0.00	0	87	1.00	1.00	0.00
Initial return	658	25.54	12.29	57.44	577	25.71	12.20	57.54	81	24.29	12.38	57.06
Firm patent	717	1.90	0.00	6.69	630	1.77	0.00	6.93	87	2.83	1.00	4.50
Firm citation	717	49.61	0.00	183.60	630	41.79	0.00	166.34	87	106.21**	4.00	273.15
Firm avg. citation	717	8.36	0.00	25.54	630	6.85	0.00	21.72	87	19.30***	2.00	42.94
Citation-weighted firm innovation	717	1.53	0.00	8.03	630	1.46	0.00	8.26	87	2.05	0.00	6.11
Market-value firm innovation	717	2.55	0.00	19.43	630	2.35	0.00	17.73	87	3.98	0.00	29.01
R&D / total assets	717	0.04	0.00	0.07	630	0.03	0.00	0.07	87	0.07***	0.06	0.08
Venture capital backed	717	0.41	0.00	0.49	630	0.40	0.00	0.49	87	0.54**	1.00	0.50
Firm age	662	18.65	9.00	24.49	583	19.92	10.00	25.69	79	9.24***	8.00	7.55
Tobin's Q	717	3.99	2.62	6.02	630	3.90	2.55	5.97	87	4.61	3.19	6.39
Underwriter rank	717	7.47	8.00	2.50	630	7.45	8.00	2.55	87	7.59	8.00	2.08
Proceeds	717	109.20	48.00	597.59	630	117.59	51.00	636.92	87	48.46	32.00	43.55

APPENDIX 3: Innovator CEOs and IPO Underpricing

Table 3

Innovator CEOs and IPO Underpricing

Table 3 presents the results of the effect of the CEO's innovative ability on IPO underpricing from 1976 to 2010. *Innovator CEO* is defined as a dummy variable equal to one if the CEO has any patents during 1975-2010. *Initial return* is defined as the closing price one day after the offering date (SDC variable: PR1DAY) divided by offering price (SDC variable: P) minus 1. If closing price one day after the offering date is missing, closing price two days after the offering date (SDC variable: PR2DAY) is used. *Firm patent* is the number of patents the CEO applied at the IPO year. Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

	Initial return (Underpricing)		
Innovator CEO	-6.091*	-4.381***	-4.237**
	(3.511)	(1.623)	(1.985)
VC	3.186	3.378	3.881
	(2.475)	(3.080)	(3.445)
Ln(firm age)	-0.780	-0.536	-0.660
	(1.173)	(0.551)	(0.639)
Tobin's Q	6.212***	6.014***	5.980***
	(0.194)	(0.164)	(0.161)
Underwriter rank	0.0853	-0.0614	-0.0167
	(0.494)	(0.494)	(0.521)
Ln(proceeds)	0.469	0.106	0.139
	(1.179)	(0.888)	(0.930)
Bubble year	17.72***	7.334	9.949
	(4.037)	(8.293)	(8.404)
High-tech industry	0.0243	-4.638*	-4.580
	(2.519)	(2.324)	(2.800)
Firm patent	0.925	1.062	1.287
	(1.446)	(1.126)	(1.138)
CEO age			-0.0643
			(0.127)
Tenure			0.00136
			(0.00949)
Year fixed effects	NO	Yes	Yes
Industry fixed effects	NO	Yes	Yes
R-square	0.719	0.732	0.735
Observations	613	613	570

APPENDIX 4: Buy-and-hold Abnormal Returns

Table 4

Buy-and-hold Abnormal Returns

Table 3 presents the buy-and-hold abnormal returns for the full sample, firms with non-innovator CEOs and firms with innovator CEOs. The benchmark returns are CRSP value-weighted index (marke_vw adj.), CRSP equal-weighted index (market-ew adj.) and a portfolio of non-IPO firms matched to IPO firms on size and market-to-book (size-MB adj.). T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

	(1)		(2)		(3)		
	Full sample (n=717)		Non-innovator CEOs (n=630)		Innovator CEOs (n=87)		(2)-(3) Difference test
Variable	Mean	p-Value	Mean	p-Value	Mean	p-Value	
AR0,1 (market-vw adj.)	32.55%	<.0001	34.01%	<.0001	21.99%	0.0136	12.02
AR0,1 (market-ew adj.)	17.31%	<.0001	19.09%	<.0001	4.46%	0.6188	14.63
AR0,1 (size-MB adj.)	26.70%	<.0001	28.33%	<.0001	14.94%	0.2253	13.39
AR0,2 (market-vw adj.)	64.42%	<.0001	61.48%	<.0001	85.68%	0.0400	-24.20
AR0,2 (market-ew adj.)	26.64%	0.0044	23.97%	0.0076	45.93%	0.2722	-21.96
AR0,2 (size-MB adj.)	63.34%	<.0001	59.79%	<.0001	88.98%	0.0404	-29.19
AR0,3 (market-vw adj.)	87.17%	<.0001	82.17%	<.0001	123.32%	0.0070	-41.15
AR0,3 (market-ew adj.)	22.58%	<.0001	18.35%	0.1316	53.19%	0.2400	-34.84
AR0,3 (size-MB adj.)	99.14%	<.0001	92.61%	<.0001	146.31%	0.0031	-53.70
AR0,4 (market-vw adj.)	123.28%	<.0001	120.33%	<.0001	144.63%	0.0023	-24.30
AR0,4 (market-ew adj.)	17.05%	0.3516	15.19%	0.4443	30.53%	0.5082	-15.34
AR0,4 (size-MB adj.)	137.66%	<.0001	130.31%	<.0001	190.86%	0.0002	-60.55
AR0,5 (market-vw adj.)	123.82%	<.0001	112.25%	<.0001	207.51%	0.0034	-95.26*
AR0,5 (market-ew adj.)	-35.57%	0.0458	-45.19%	0.0113	34.03%	0.6272	-79.22
AR0,5 (size-MB adj.)	135.85%	<.0001	119.70%	<.0001	252.68%	0.0008	-133.0**

APPENDIX 5: Calendar-Time Factor Model Regressions

Table 5

Calendar-Time Factor Model Regressions Innovator CEOs and Non-innovator CEOs

Table 4 presents the calendar-time factor model regressions using Fama-French three-factor model (1993), Fama-French five-factor model (2016), and Fama-French three-factor model (1993) purged IPO and SEO firms for IPO firms. The five-factor model is $R_{pt} - r_{ft} = a + b(R_{mt} - r_{ft}) + sSMB_t + hHML_t + rRMW_t + cCMA_t + e_t$, where R_{pt} is the monthly return for an equal-weighted calendar-time portfolio of IPOs in month t, R_{mt} is the monthly return on the CRSP value-weighted market index in month t, r_{ft} is the monthly return on the three-month Treasury bills in month t, $(R_{mt} - r_{ft})$ is the market risk premium MRP, SMB_t is the monthly return on a value-weighted portfolio of small firms minus the return on a value-weighted portfolio of large firms in month t, HML_t is the monthly return on a value-weighted portfolio of high book-to-market stocks minus the return on a value-weighted portfolio of low book-to-market stocks in month t, $rRMW_t$ is the monthly return on a value-weighted portfolio of high operating profitability stocks minus the return on a value-weighted portfolio of low operating profitability stocks in month t, and $cCMA_t$ is the monthly return on a value-weighted portfolio of conservative investment stocks minus the return on a value-weight portfolio of aggressive investment stocks. The intercept (a) represents the abnormal performance. I calculate the returns for the portfolio of IPO firms for the period of 0-36 months after IPO. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

	(1) Full sample			(2) Non-innovator CEOs			(3) Innovator CEOs		
	Three-factor model Fama and French (1993)	Five-factor model Fama and French (2014)	Fama-French 3-factor model purged IPO and SEO firms	Three-factor model Fama and French (1993)	Five-factor model Fama and French (2014)	Fama-French 3-factor model purged IPO and SEO firms	Three-factor model Fama and French (1993)	Five-factor model Fama and French (2014)	Fama-French 3-factor model purged IPO and SEO firms
MRP	1.231***	1.191***	1.346***	1.111***	1.098***	1.245***	1.394***	1.298***	1.589***
	(0.0681)	(0.0731)	(0.100)	(0.104)	(0.107)	(0.140)	(0.0719)	(0.0801)	(0.0989)
SMB	0.968***	0.982***	1.059***	1.317***	1.283***	1.399***	0.839***	0.756***	0.920***
	(0.101)	(0.108)	(0.136)	(0.178)	(0.185)	(0.233)	(0.105)	(0.113)	(0.130)
HML	-0.438***	-0.290**	-0.358**	-0.413**	-0.386*	-0.308	-0.850***	-0.629***	-0.805***
	(0.101)	(0.136)	(0.164)	(0.169)	(0.226)	(0.288)	(0.107)	(0.143)	(0.163)
RMW		-0.00958			-0.210			-0.337**	
		(0.134)			(0.312)			(0.145)	
CMA		-0.349			-0.176			-0.373*	
		(0.213)			(0.363)			(0.213)	
Intercept	0.900***	0.990***	0.764*	0.648	0.760	0.282	1.502***	1.775***	1.192***
	(0.298)	(0.309)	(0.399)	(0.436)	(0.462)	(0.576)	(0.329)	(0.341)	(0.400)

APPENDIX 6: Multivariate Regression Explaining IPO Long-Run Performance

Table 6

Multivariate Regression Explaining IPO Long-Run Performance

Table 5 presents the results of the effect of the CEO's innovative ability on IPO long-run performance from 1976 to 2010. *CEO avg. citation* is defined as the ratio of CEO citation over CEO patent at the IPO year. AR0,3 is the buy-and-hold abnormal returns for 3-year holding period after IPO. The benchmark return is CRSP value-weighted index, CRSP equal-weighted index, and style-matched firms return based on size and book-to-market ratio. *High-tech industry* is a dummy variable equal to one if the firm is in the high technological industry. The definition of high technological industry follows Loughran and Ritter (2004). Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

	AR0,3								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Market-vw adj.	Market-ew adj.	Size-BM adj.	Market-vw adj.	Market-ew adj.	Size-BM adj.	Market-vw adj.	Market-ew adj.	Size-BM adj.
CEO avg. citation	3.000***	2.987***	3.101***	3.077***	3.063***	3.175***	-3.102*	-2.842*	-2.875**
	(10.80)	(10.71)	(12.25)	(12.89)	(12.73)	(14.32)	(-1.88)	(-1.74)	(-2.34)
High-tech industry	-34.27	-34.29	-49.51	-18.61	-18.78	-34.28			
	(-1.18)	(-1.17)	(-1.23)	(-0.63)	(-0.63)	(-0.86)			
Same class							-40.19	-40.33	-78.68
							(-0.78)	(-0.77)	(-1.37)
CEO avg. citation * High-tech industry				-7.262**	-7.191**	-7.061**			
				(-3.20)	(-2.93)	(-3.21)			
CEO avg. citation * same class							6.201***	5.927***	6.126***
							(3.87)	(3.73)	(5.03)
VC	44.45**	46.05**	36.71	42.33**	43.95**	34.65	41.88*	43.63**	34.64
	(2.11)	(2.16)	(1.27)	(2.04)	(2.10)	(1.23)	(1.98)	(2.05)	(1.22)
Ln(firm age)	-7.955	-7.291	-0.752	-8.905	-8.231	-1.675	-9.348	-8.619	-1.990
	(-0.67)	(-0.61)	(-0.06)	(-0.73)	(-0.67)	(-0.13)	(-0.78)	(-0.71)	(-0.16)
Initial return	0.746	0.773	0.811	0.785	0.811	0.848	0.770	0.795	0.826
	(1.20)	(1.26)	(1.28)	(1.28)	(1.35)	(1.37)	(1.28)	(1.34)	(1.32)
Tobin's Q	-8.432**	-8.560**	-7.540*	-8.574**	-8.700**	-7.677*	-8.429**	-8.548**	-7.352*
	(-2.16)	(-2.22)	(-1.93)	(-2.21)	(-2.27)	(-1.97)	(-2.20)	(-2.26)	(-1.86)
Underwriter rank	-0.748	-0.958	-4.854	-0.847	-1.057	-4.951	-0.590	-0.800	-4.617
	(-0.16)	(-0.21)	(-1.15)	(-0.19)	(-0.23)	(-1.18)	(-0.13)	(-0.17)	(-1.08)
Ln(proceeds)	-51.81**	-50.34**	-75.63***	-51.17**	-49.70**	-75.00***	-51.97**	-50.54**	-77.08***
	(-3.14)	(-3.11)	(-4.24)	(-3.00)	(-2.97)	(-4.07)	(-3.03)	(-3.01)	(-4.32)
Bubble year	49.40	-35.01	27.61	50.21	-34.21	28.40	51.48	-32.90	33.36
	(0.67)	(-0.49)	(0.45)	(0.67)	(-0.47)	(0.45)	(0.70)	(-0.46)	(0.50)
CEO age	-0.856	-0.923	-1.135	-0.801	-0.868	-1.081	-0.895	-0.963	-1.241
	(-0.40)	(-0.44)	(-0.49)	(-0.39)	(-0.43)	(-0.48)	(-0.44)	(-0.48)	(-0.56)
Tenure	-0.149	-0.161	-0.165	-0.140	-0.152	-0.156	-0.144	-0.155	-0.151
	(-0.99)	(-1.09)	(-1.05)	(-0.97)	(-1.07)	(-1.03)	(-1.06)	(-1.17)	(-1.03)
Firm innovation03	2.322*	2.331*	1.799*	1.550	1.560	1.499*	1.609	1.617	1.626**
	(1.85)	(1.89)	(1.68)	(1.38)	(1.38)	(1.87)	(1.41)	(1.41)	(2.12)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-square	0.130	0.155	0.136	0.219	0.244	0.230	0.217	0.242	0.230
Observations	569	569	569	569	569	569	569	569	569

APPENDIX 7: Innovator CEOs, High-tech Industry, and Firms Post-IPO Performance

Table 7

Innovator CEOs, High-tech Industry, and Firms Post-IPO Performance

Table 6 presents the results of the effect of the CEO's innovative ability on IPO long-run performance from 1976 to 2010. *Innovator CEO* is defined as a dummy variable equal to one if the CEO has any patents during 1975-2010. *Capital expenditure / total assets* is defined as capital expenditures divided by total assets. *Cash / total assets* is defined as cash holdings divided by total assets. *R&D / total assets* is defined as research and development expenditures divided by total assets. If R&D is missing, R&D is equal to zero. *High-tech industry* is a dummy variable equal to one if the firm is in the high technological industry. The definition of high technological industry follows Loughran and Ritter (2004). Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

	Cash / total assets (t+3)		R&D / total assets (t+3)	
	(1)	(2)	(3)	(4)
Innovator CEO	-0.00902	0.0449	0.0283***	0.0480***
	(0.0259)	(0.0363)	(0.00972)	(0.0135)
Innovator CEO * High-tech industry		-0.106**		-0.0396**
		(0.0504)		(0.0189)
High-tech industry	0.0361	0.0594*	0.0172	0.0261**
	(0.0321)	(0.0338)	(0.0122)	(0.0128)
VC	0.0871***	0.0906***	0.0196***	0.0207***
	(0.0197)	(0.0196)	(0.00731)	(0.00730)
Ln(firm age)	0.00814	0.00936	0.00332	0.00362
	(0.00995)	(0.00991)	(0.00359)	(0.00357)
Tobin's Q	0.00519**	0.00551**	0.000111	0.000230
	(0.00238)	(0.00237)	(0.000903)	(0.000900)
Underwriter rank	-0.00114	-0.000611	1.66e-05	0.000214
	(0.00367)	(0.00366)	(0.00139)	(0.00138)
Ln(proceeds)	0.0181	0.0184	0.00663	0.00678
	(0.0147)	(0.0146)	(0.00550)	(0.00548)
Ln(sales)	-0.0606***	-0.0590***	-0.0102***	-0.00966**
	(0.0101)	(0.0101)	(0.00382)	(0.00381)
Ln(ROA)	0.0245***	0.0238***	0.00402	0.00383
	(0.00723)	(0.00719)	(0.00273)	(0.00272)
CEO age	-0.00144	-0.00138	-0.000310	-0.000291
	(0.00122)	(0.00121)	(0.000453)	(0.000451)
Tenure	1.67e-05	4.51e-05	-4.13e-05	-3.17e-05
	(0.000139)	(0.000139)	(4.69e-05)	(4.68e-05)
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
R-square	0.582	0.588	0.500	0.507
Observations	357	357	373	373

APPENDIX 8: Innovator CEOs and Post-IPO Firm Innovation

Table 8

Innovator CEOs and Post-IPO Firm Innovation

Table 6 presents the results of the effect of the CEO's innovative ability on IPO long-run performance from 1976 to 2010. *Innovator CEO* is defined as a dummy variable equal to one if the CEO has any patents during 1975-2010. *Firm patent* is the number of patent the firm applied two or three years after the IPO. *Firm citation* is the number of citations subsequently received by the patents the firm applied two or three years after the IPO. *Firm avg. citatio* is defined as the nature log of the ratio of firm citation over firm patent two or three years after the IPO. *Citation-weighted firm innovation* is the sum of the weight of citations on each patent plus one for firm i divided by book assets of firm i two or three years after the IPO. *Market-value firm innovation* is total dollar value of innovation produced by firm i divided by book assets of firm i two or three years after the IPO. Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

	Two years after the IPO					Three years after the IPO				
	Log (1 + Firm patent)	Log (1 + Firm citation)	Log (1 + Firm avg. citation)	Log (1 + Citation-weighted firm innovation)	Log (1 + Market-value firm innovation)	Log (1 + Firm patent)	Log (1 + Firm citation)	Log (1 + Firm avg. citation)	Log (1 + Citation-weighted firm innovation)	Log (1 + Market-value firm innovation)
Innovator CEO	0.193**	0.568***	0.440***	0.208*	0.0388	0.0268	0.258	0.297**	0.211*	0.0478
	(0.0920)	(0.215)	(0.156)	(0.118)	(0.128)	(0.0986)	(0.215)	(0.147)	(0.123)	(0.145)
VC	0.183***	0.517***	0.372***	0.168**	0.0818	0.215***	0.443***	0.318***	0.195**	0.234**
	(0.0651)	(0.152)	(0.110)	(0.0834)	(0.0904)	(0.0697)	(0.152)	(0.104)	(0.0871)	(0.103)
Ln(firm age)	-0.0525*	-0.106	-0.0508	-0.120***	-0.104**	-0.0454	-0.0928	-0.0431	-0.0939**	-0.0967**
	(0.0310)	(0.0725)	(0.0526)	(0.0398)	(0.0431)	(0.0333)	(0.0727)	(0.0496)	(0.0415)	(0.0490)
Tobin's Q	0.0318***	0.0630***	0.0331***	0.0114*	0.0256***	0.0342***	0.0552***	0.0215***	0.0296***	0.0296***
	(0.00493)	(0.0115)	(0.00836)	(0.00633)	(0.00685)	(0.00529)	(0.0116)	(0.00789)	(0.00661)	(0.00779)
Underwriter rank	0.0164	0.0271	0.0105	0.0189	0.0328*	0.0267**	0.0446	0.0210	0.0246	0.0316
	(0.0125)	(0.0293)	(0.0212)	(0.0161)	(0.0174)	(0.0134)	(0.0293)	(0.0200)	(0.0168)	(0.0198)
Ln(proceeds)	0.0638*	0.167*	0.0949	0.0418	0.110**	0.0493	0.115	0.0669	0.0776	0.129**
	(0.0375)	(0.0876)	(0.0636)	(0.0481)	(0.0521)	(0.0402)	(0.0878)	(0.0600)	(0.0502)	(0.0592)
Bubble year	0.0881	0.327	0.280	0.0447	-0.0934	0.167	0.299	0.207	0.364	0.152
	(0.210)	(0.490)	(0.356)	(0.269)	(0.291)	(0.225)	(0.491)	(0.335)	(0.281)	(0.331)
High-tech industry	0.355***	1.018***	0.728***	0.435***	0.416***	0.361***	0.974***	0.686***	0.487***	0.498***
	(0.0665)	(0.155)	(0.113)	(0.0852)	(0.0923)	(0.0713)	(0.156)	(0.106)	(0.0890)	(0.105)
CEO age	-0.00140	0.000618	0.00180	0.00827	0.00354	-0.00627	-0.00650	0.000873	0.00838	0.00298
	(0.00402)	(0.00938)	(0.00681)	(0.00515)	(0.00558)	(0.00431)	(0.00941)	(0.00642)	(0.00538)	(0.00634)
Tenure	5.73e-05	0.000234	0.000376	-0.000182	-0.000242	-0.000141	-0.000363	-0.000113	0.000541	0.000528
	(0.000442)	(0.00103)	(0.000749)	(0.000567)	(0.000614)	(0.000474)	(0.00104)	(0.000707)	(0.000592)	(0.000698)
Firm patent one year before IPO	0.106***	0.151***	0.0478***	0.129***	0.154***	0.104***	0.132***	0.0366***	0.127***	0.148***
	(0.00654)	(0.0153)	(0.0111)	(0.00839)	(0.00908)	(0.00701)	(0.0153)	(0.0105)	(0.00875)	(0.0103)
		Yes					Yes			
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-square	0.556	0.476	0.379	0.479	0.508	0.543	0.441	0.358	0.485	0.460
Observation	612	612	612	612	612	612	612	612	612	612

APPENDIX 9: Propensity score matching results

Table 9

Innovator CEOs, Underpricing, and Post-IPO firm innovation--Propensity score matching results

Table 10 presents the effects of innovator CEOs on underpricing, post-IPO firm innovation from propensity score matching results. *Initial return* is defined as the closing price one day after the offering date (SDC variable: PR1DAY) divided by offering price (SDC variable: P) minus 1. If closing price one day after the offering date is missing, closing price two days after the offering date (SDC variable: PR2DAY) is used. *Firm patent* is the number of patent the firm applied two or three years after the IPO. *Firm citation* is the number of citations subsequently received by the patents the firm applied two or three years after the IPO. *Firm avg. citatio* is defined as the nature log of the ratio of firm citation over firm patent two or three years after the IPO. *Citation-weighted firm innovation* is the sum of the weight of citations on each patent plus one for firm i divided by book assets of firm i two or three years after the IPO. *Market-value firm innovation* is total dollar value of innovation produced by firm i divided by book assets of firm i two or three years after the IPO.Variable definitions are provided in the Appendix. T-statistics are reported in parentheses. Statistical significance at the 1%, 5%, and 10% levels is denoted by ***, **, and *, respectively.

			Three years									
	Initial return (Underpricing)		Log (1 + Firm patent)		Log (1 + Firm citation)		Log (1 + Firm avg. citation)		Log (1 + Citation-weighted firm innovation)		Log (1 + Market-value firm innovation)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(9)	(10)
Innovator CEO	-4.634	-6.232*	0.450***	0.483***	1.165***	1.240***	0.843***	0.888***	0.698***	0.720***	0.531**	0.573**
	(4.039)	(3.496)	(0.165)	(0.164)	(0.403)	(0.403)	(0.266)	(0.267)	(0.265)	(0.267)	(0.231)	(0.233)
Nearest matching	1	2	1	2	1	2	1	2	1	2	1	2
Other control variables	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
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
Observations	570	570	612	612	612	612	612	612	612	612	612	612

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B.S. in Economics and B.S. in Accounting 2007 - 2011
Guangdong University of Foreign Studies, Guangzhou, China

Research Interests

Corporate Finance, Corporate Innovation, IPOs, Corporate Governance and Investment

Publication

Lin, Z., Van Ness, B.F. and Van Ness, R.A., 2018. Canceled Orders and Executed Hidden Orders. *The Journal of Trading*, *13*(2), pp.5-19.

Working Papers

1. CEOs with Innovative Ability (Job Market Paper)
   - 2018 Financial Management Association (FMA) Annual Meeting

2. Do IPO Costs Affect Innovation? (with Kathleen P. Fuller)
   - 2018 Southern Finance Association (SFA) Annual Meeting (scheduled)
   - 2017 Financial Management Association (FMA) Annual Meeting
   - 2017 Eastern Finance Association (EFA) Annual Meeting
   - Submitted to the *Journal of Banking and Finance* (August 2018)

3. Talent Cycling in IPOs

4. Momentum and Information
    - 2017 Southwestern Finance Association (SWFA) Annual Meeting

Work in Progress

1. Innovator CEOs in IPOs

2. Patent-backed Financing (with Seong Byun)

3. M&A and the Outflow of Talent (with Sean C. Cao)

4. Horserace of CEOs or CTOs with Innovative Ability (with Sean C. Cao)

Teaching Experiences

University of Mississippi, University, MS

Instructor

FIN 361 Quantitative Financial Analysis (online)
- Fall 2018
  Scheduled

FIN 331 Business Finance I
- Fall 2018
  Scheduled
- Summer 2018 (2 sections)
  Scheduled
- Summer 2017 — Teaching evaluations: 5/5
- Spring 2017 — Teaching evaluations: 4/5
- Fall 2016 — Teaching evaluations: 4/5
- Summer 2016 — Teaching evaluations: 4/5
- Summer 2015 — Teaching evaluations: 5/5

FIN 334 Investments
- Spring 2018 (2 sections) — Teaching evaluations: 4/5
- Fall 2017 (2 sections) — Teaching evaluations: 4/5

Teaching Assistant

FIN 361 Quantitative Financial Analysis (online) — 2016 – 2018 (9 times)
FIN 334 Investments — 2015 – 2016 (2 times)

University of Massachusetts-Boston, Boston, MA

Teaching Assistant

AF 335 Student Managed Fund — 2013 – 2014 (2 times)
AF 499 College of Management Honors Thesis Seminar — Fall 2013
MKT 301 Principles of Marketing — Spring 2013

Teaching Technology

Blackboard, Pearson MyLab, Aplia, MindTap

Presentations

1. "CEOs with Innovative Ability", Financial Management Association (FMA) Annual Meeting, San Diego, California, 2018.
2. "CEOs with Innovative Ability", University of Mississippi and University of Memphis Joint Seminar, 2018.

3. "Do IPO Costs Affect Innovation?" (with Kathleen P. Fuller), Financial Management Association (FMA) Annual Meeting, Boston, Massachusetts, 2017.

4. "Do IPO Costs Affect Innovation?" (with Kathleen P. Fuller), Eastern Finance Association (EFA) Annual Meeting, Jacksonville, Florida, 2017.

5. "Canceled Orders and Executed Hidden Orders" (with Bonnie Van Ness and Robert A. Van Ness), Eastern Finance Association (EFA) Annual Meeting, Jacksonville, Florida, 2017.

6. "Canceled Orders and Executed Hidden Orders" (with Bonnie Van Ness and Robert A. Van Ness), Southwestern Finance Association (SWFA) Annual Meeting, Little Rock, Arkansas, 2017.
7. "Momentum and Information", Southwestern Finance Association (SWFA) Annual Meeting, Little Rock, Arkansas, 2017.

Conference and Service

2018 Financial Management Association (FMA), Annual Meeting	Discussant
2017 Southwestern Finance Association (SWFA), Annual Meeting	Discussant/Session Chair
2017 Eastern Finance Association (EFA), Annual Meeting	Discussant
2016 Financial Management Association (FMA), Annual Meeting	Discussant/Session Chair

Awards and Scholarships

Graduate Teaching and Research Assistant	University of Mississippi	2014-present
Graduate School Travel Grant	University of Mississippi	2016-present
Graduate Achievement Award for Ph.D. Degree	University of Mississippi	2017
Graduate Teaching and Research Assistant	University of Massachusetts-Boston	2013-2014
Beta Gamma Sigma Honor Society Member	University of Massachusetts-Boston	2013
Merit-based Scholarship Recipient	Guangdong University of Foreign Studies	2008

Non-Academic Experience

Treasurer, Graduate Student Assembly, University of Massachusetts-Boston	2013
Intern, Department of Trade Finance, Head Office of China Everbright Bank	2009

Programming, and Language Skills

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