Inventor CEOs and Initial Public Offerings

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Abstract

About one in five high-technology firms that successfully go public in the US are led by CEOs with hands-on experience as inventors. Despite being smaller, less profitable, and more R&D intensive, these firms experience lower first-day returns or underpricing at the time of their initial public offering (IPO) compared to other technology firms. In the three years following the IPO, inventor-led firms produce better innovation outputs as measured by the number of total patents generated and the number of breakthrough patents. They also experience large positive risk-adjusted stock returns during the post-IPO period. These associations continue to hold in a subset of IPOs led by founder CEOs as well as in a propensity score matched sample, suggesting that the effects are causal. Our findings are consistent with the idea that inventor CEOs can communicate the intrinsic value of their firms' innovation to external investors more credibly and are better at managing their firms' transition from private to public entities.

JEL classification: G12, G14, G23, O31
Keywords: Initial public offering, Inventor CEO, Innovation, Underpricing, Post-IPO stock returns.

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1. Introduction

Many prominent and successful technology firms in the US are led by CEOs that have personal hands-on experience in innovation. Examples include Tesla, Amazon, Google, Gateway, Intel, Microsoft, and Oracle, among others. Such prevalence of inventor CEOs raises the question as to whether a CEO's personal involvement with innovation plays any role in the success of a firm. A recent study by Islam and Zein (2020) attempts to answer this question. Using a sample of large, listed US technology firms, they document evidence that firms led by inventor CEOs are more successful at innovation as evidenced by the greater number of patents they register and greater number of citations these patents receive. The authors draw upon learning-by-doing literature to explain their findings and argue that CEOs' inventor experience endows them with valuable innovation-related insights that translate into a superior ability to evaluate and execute innovation-intensive investment projects.

In this paper, we build on this nascent research and examine the role of inventor CEOs in the initial public offerings (IPOs) of technology firms.[1] We explore three questions. First, we investigate whether inventor CEOs are able to convey information about the intrinsic value of their firms' innovation capital more credibly to outsiders at the time of IPO, thereby lowering the uncertainty for investors. The innovation capital of start-up firms tends to be intangible, idiosyncratic, and largely embedded in the heads of the employees (Hall, 2010). Personal involvement of the CEOs with innovation may therefore allow them to better understand its complexity and prospects, and enable them to more effectively communicate its value to external financiers. We test this hypothesis by comparing the underpricing of the firms that inventor CEOs take to the market with those of other high-technology firm IPOs, because underpricing is often linked to the uncertainty of firm valuation at the time of IPO (Ritter, 1984; Rock, 1986; Lowry, Officer and Schwert, 2010; Loughran and McDonald, 2013). Second, we ask whether inventor CEOs manage firms' R&D investments better and generate superior innovation outcomes during the three-year post-IPO period. This is the period in which firms typically make major new investments, which lead to new information and continual reassessment of the risks and opportunities associated with innovation (Hall, 2010). Third, we ask whether the stock market

[1] Approximately 40% of all firms that have gone public in the US in recent decades are technology firms (Bernstein, 2015).

fully understands the influence of inventor CEOs on post-IPO firm innovation and examine the abnormal stock returns of the IPOs led by inventor CEOs in the three-year post-IPO period.

It is useful to examine the role of inventor CEOs in the context of IPOs for several reasons. First, an IPO represents an important transformational event in the life of a technology firm and understanding the determinants of its success can bring practical benefits to the sponsors of these firms. Second, as Baker and Gompers (2003) note, evaluating the effectiveness of alternative governance structures (i.e., CEO characteristics in our context) around corporate events such as IPOs is beneficial, as in calendar time, governance structures are as much a consequence of past performance as they are of governance quality. Finally, it is useful to revisit the role of inventor CEOs in the context of an IPO because theoretical arguments are not unequivocal regarding the role inventor CEOs play during a firm's IPO. While technically adept, it is possible that inventor CEOs' narrow focus and tunnel vision make them less suitable to communicate effectively with underwriters and fund managers. Inventors may also be less capable of commercializing their firms' innovation (Rothwell, 1977), which can be critical for the post-IPO success of the newly-listed firms. Venture capitalists, for instance, sometimes replace technical founders with professional management teams for related reasons (Hellmann and Puri, 2002). Therefore, whether hands-on involvement of CEO in innovation is useful or detrimental for a high technology firm's IPO remains an open empirical question.

We assemble a novel hand-collected data set that tracks the patenting history of CEOs that were at the helm of the US high-technology firms at the time of their IPOs during 1992–2010. CEOs that possess at least one patent in their own name at the time of the IPO are designated as "Inventor CEOs". The US technology sector accounts for more than half of all IPOs in the US during our sample period. About 19% of the IPOs within this sector are led by inventor CEOs.[2] We find that these IPOs involve firms that are smaller, younger, less profitable, and more R&D-intensive compared to other high technology IPOs led by non-inventor CEOs. These characteristics are typically associated with greater risk and uncertainty. The fact that inventor CEOs can successfully take riskier technology firms to the market provides tentative support to the idea that

[2] Many inventor CEOs that led their companies' IPOs in our sample went on to become prominent names in their industries. These include Jeffrey P. Bezos of Amazon.com, Elon Musk of Tesla, Jen-Hsun Huang of Nvidia Corp, Reed Hastings of Netflix Inc., Colin M. Angle of Irobot Corp, and Michael Chasen of Blackboard Inc.

inventor CEOs are better at reducing the information uncertainty about the value of their firms' innovation through more credible communication with investors.

To further explore this relationship, we examine how underpricing of the IPO is associated with the inventor status of the CEO. As firms led by inventor CEOs tend to be smaller, less profitable, and more R&D intensive, one might expect that IPOs led by inventor CEOs would experience greater underpricing as these characteristics are linked with greater underpricing in the extant IPO literature (see, for example, Ritter and Welch, 2002; Lowry, Officer and Schwert, 2010). Yet, in our multivariate regressions, we find that IPOs led by inventor CEOs are associated with less underpricing than other IPOs. The inventor status of the CEO is associated with about 3% less underpricing, which is economically meaningful when compared to the average underpricing of 18% in our sample (excluding the Internet bubble period). Thus, the evidence suggests that inventor CEOs are better at explaining the nature and valuation of their firms' innovation investments to underwriters and institutional investors. In the cross-section, this ability of inventor CEOs is expected to be especially useful for communicating the value of those firms that are more R&D intensive. Consistent with this expectation, we find that the negative association between inventor CEOs and underpricing is more pronounced among firms with greater R&D intensity. Among the firms that have above-median R&D intensity in our sample, underpricing is about 9% lower for inventor-led firms than that of the non-inventor-led firms.

Turning to the post-IPO performance, we find that in the three years following the IPO firms led by inventor CEOs produce superior innovation outcomes across several dimensions. They not only produce a higher number of total patents but also produce greater number of ground-breaking or disruptive innovations as evidenced by their greater propensity to produce patents that are cited in the 95^{th} percentile of the citation distribution within their technology class-year. There is also some evidence that the patents generated by these firms are more impactful in that they receive a greater number of future citations. All these results are obtained after controlling for the level of R&D expenditure and past success with innovation at the time of IPO.

Interestingly, the stock market seems unable to recognize the importance of the inventor CEOs for the newly-listed firms' future innovation. Using a calendar-time portfolio approach and Fama–French three factor model, we find that the average abnormal stock return during the three-

year post-IPO period for the inventor-led firms is 0.83% per month (10.43% annualized). The magnitude of this return is striking given evidence of insignificant or negative abnormal return for a typical US IPO documented in the previous literature (Ritter and Welch, 2002).

The correlations we document between inventor CEOs and IPO outcomes can be interpreted in at least two ways. First, firms with higher innovation potential may choose to hire inventor CEOs because they have the relevant skillset to successfully guide the firm in its transition from a private to a public entity. Second, inventor CEOs' personal hands-on involvement with firms' innovation endows them with specialized knowledge, which enables them to communicate the value of firms' innovation capital to outsiders more credibly and better manage the growth of this capital during firms' transition. Notably, both interpretations imply that inventor CEOs possess a unique skillset to manage technology firms' transition to a public entity. Therefore, we believe that the correlations we document are in and of themselves informative.

Nevertheless, in order to explore the causal interpretation we conduct three additional analyses. First, we examine the subset of firms whose CEOs are also the founders. The presence of a founder CEO mitigates the concern that the CEO was appointed around the time of IPO to manage the firm transition. Within this founder-only sample, we obtain results that are similar to those reported earlier. Second, we utilize the propensity score matching and estimate the average effect of the treatment on the treated (*ATT*) to evaluate the effect of inventor CEOs on underpricing and post-IPO innovation. We find that the results obtained from the propensity score matched sample are, in general, greater in economic magnitude than those reported earlier. Lastly, we find that in the cross-section our results are more pronounced for more impactful inventor CEOs as identified from the number of future citations their innovations received.

Our results extend the evidence provided by Islam and Zein (2020) regarding the positive influence of inventor CEOs on technology firms. We first show that the relationship between inventor CEO and future firm innovation that they document for the large, listed firms also holds for the newly-listed technology firms during their transition years. We then provide novel evidence on IPO underpricing, which suggests that inventor CEOs may be better at communicating the value of their firm's innovation to external financiers. Importantly, we also show that the stock market does not fully understand the positive influence of inventor CEOs on future innovation and firms

led by inventor CEOs experience positive abnormal stock returns during the three-year post-IPO period. The latter finding ties our work to previous studies by Hirshleifer, Hsu and Li (2013, 2018) and Cohen, Diether and Malloy (2013), which find that the stock market fails to fully understand predictors of future firm innovation, and hence these predictors also forecast firms' abnormal stock returns. Unlike the predictors used in these studies, which are all constructed from firms' past innovation history, the predictor we employ is a personal trait of CEOs.

We contribute to the IPO literature by providing a novel human-capital-based explanation for why some technology firms are more successful than others in their transition from private to public entities. Prior IPO literature has looked at determinants of IPO underpricing and long-term performance including the roles of venture capitalists, underwriters, and analysts (see, for example, Ritter and Welch, 2002 for a review paper). Yet, the attempts to link within-firm human capital to IPO outcomes have been limited. Chemmanur and Paeglis (2005) document that IPOs with a superior quality of management teams experience better outcomes. They define a management team as the officers with the rank of vice president or higher and measure its quality by looking at factors such as the resources available and the structure of the management team. Their work analyzes aggregated attributes of the management team as a whole and IPOs in general. They do not focus on CEOs and do not study outcomes specific to technology IPOs such as the success of their innovation. Gao and Jain (2012) examine the relationship between the founder status of CEOs and post-IPO stock returns. We control for the effect of founder CEOs in all our analyses. In general, the effects of inventor CEOs that we document appear more encompassing than many previously documented determinants of the IPO success as they are discernable both at the time of IPO and during the post-IPO period.

The rest of this paper is structured as follows. Section 2 reviews relevant literature and develops the hypotheses. Section 3 describes the procedure we follow to assemble our dataset and construct variables. Section 4 presents the baseline results. Section 5 presents the analyses that address endogeneity concerns. Finally, Section 6 concludes the paper.

2. Related Literature and Hypotheses

Personal communication by CEOs can be an important source of information for investors for high technology IPOs. During the common practice of "book building", which typically lasts for around four weeks, the top management of the issuer joins underwriters to go on a "road show" to market the company to prospective buyers. During the road show, investors get a chance to hear about the firm's operations, valuation, and future plans directly from the CEO and other top management. A CEO with superior knowledge can discuss the firm's valuation and intricacies more credibly to the outside investors and respond to inventor queries. Personal communication by top management can prove useful because other avenues for sharing insights about a firm's innovation capital with potential investors may be limited. Start-up firms are young, so they do not have time to develop a reputation that would allow them to signal their quality adequately. Reducing information asymmetry via full disclosure in prospectus may also be impossible due to the fear of imitation by competitors (Bhattacharya and Ritter, 1983). Finally, even though asymmetric information problems can sometimes be mitigated by specialized venture capital funds owing to their role as informed monitors of early stage technology startups, experienced VCs often develop a reputation for honoring nondisclosure agreements that enable them to gather better information about projects being proposed (Hall, 2010).

As noted previously, the learning-by-doing literature suggests that the hands-on experience of inventor CEOs endows them with unique insights about the complexities of firms' technology and prospects that cannot otherwise be gained (Arrow, 1962; Irwin and Klenow, 1994; Thompson, 2010; Islam and Zein, 2020). In addition, the presence of an inventor at the top makes the transfer of knowledge from lower segments of the innovation process towards the top more efficient (Grant, 1996), which provides the top management with a superior understanding of the firm's innovation projects. Conversely, it is also possible that inventor CEOs personal involvement with R&D makes them more fixated on technicalities and less aware of the latest customer and market needs (Rothwell, 1977), making them less suitable for marketing their firms to investors. Thus, theories produce contrasting predictions on whether inventor CEOs can help reduce uncertainty for investors at the time of an IPO.

Therefore, the first question we ask is whether CEOs' personal hands-on experience of innovation influences their ability to credibly communicate the value of the firms' innovation to outsiders. If the effect is positive, that is, the inventor CEO is more effective in explaining firm

valuation, investors in inventor-led IPOs would face less valuation uncertainty. To test this hypothesis, we compare the underpricing of the IPOs led by inventor and non-inventor CEOs. Several theoretical models propose that underpricing is an efficient response to the complexity of the valuation problem investors face when investing in the equity of private companies that have uncertain prospects and are difficult to value (Rock, 1986; Beatty and Ritter, 1986; Welch, 1992; Benveniste and Spindt, 1989). Empirical work has largely supported this idea by demonstrating that IPOs characterized by greater uncertainty experience greater underpricing (see, for example, Ritter and Welch, 2002; Lowry, Officer and Schwert, 2010). We therefore posit that if inventor CEOs are better able to reduce valuation uncertainty, IPOs led by them would experience lower underpricing.

The inventor status of the CEO may also influence the innovation performance of a firm during the post-IPO period. Islam and Zein (2020) advance arguments and provide supporting evidence that inventor CEOs possess superior ability to evaluate, select, and execute innovation-intensive investment projects. If so, one might expect this advantage to lead to even more discernable differences in the innovation outcomes during the post-IPO period. The management of innovation tends to be a dynamic process for newly-listed firms because these firms typically make significant new investments that change the nature of uncertainty about the firms' innovation output (Hall, 2010). This in turn leads to continual reassessment of the innovative investments and makes them resemble real options. The superior knowledge of inventor CEOs may give firms an edge in managing these real options.[3] Moreover, Adler and Borys (1996) argue that inventor CEOs are better at aligning incentives for scientists working in the firm and limiting the exodus of vital innovators in the post-IPO period, which Bernstein (2015) document to be the primary reason for the decline of innovation in technology firms during the post-IPO period.[4] Finally, Balsmeier, Fleming and Manso (2017) note that the passion and knowledge of inventor CEOs can be useful in developing partnerships with external parties to market or commercialize firms' innovation.

[3] Echoing this logic, Bennedsen, Perez and Wolfenzon (2020) find evidence that a CEO's personal effects are stronger for growing firms.

[4] Rothwell (1997) argues that personal enthusiasm for R&D and intrinsic motivation allows inventor CEOs to nurture an innovation-centric culture that encourages risk taking and experimentation across various layers of the organization, which can induce superior innovation investments during the post-IPO period.

Conversely, it can also be argued that personal involvement of inventor CEOs in firm innovation may exacerbate the well-known moral hazard problem, whereby inventor-led new listings overinvest their newly-raised capital in innovation, especially in projects that CEOs are personally associated with to satisfy their egos rather than in projects that are commercially desirable.[5] This can make the post-IPO performance worse for inventor-led firms relative to other firms. To disentangle the opposing predictions, we utilize several measures of the success of innovation commonly used in the innovation literature, including the number of patents the firm generates and the number of future citations these patents receive. We compare the change in these measures for inventor-led IPOs during the post-IPO period with the corresponding change for non-inventor-led IPO after controlling for other known determinants of innovation.

Our last hypothesis revolves around the abnormal stock returns generated by IPOs led by inventor CEOs in the three-year period following the IPO. If the stock market fails to fully appreciate the influence of an inventor CEO on future firm innovation, the firm's shares would be mispriced at the time of listing and we expect them to generate abnormal stock returns during the post-IPO period. Prior work suggests that the stock market does not always understand the predictability of future innovation, and hence factors that predict innovation also predict future stock returns. Hirshleifer, Hsu and Li (2013) find that a firm's innovative efficiency—which they define as patents or citations scaled by research and development expenditures—predicts higher future innovation as well as positive future stock returns. In a subsequent paper, Hirshleifer, Hsu and Li (2018) identify innovation originality as another variable that predicts both future firm innovation and stock returns. Likewise, Cohen, Diether and Malloy (2013) develop simple measures of a firm's past success in innovation and show that it predicts both future innovation and stock returns.

IPOs led by inventor CEOs may also generate positive abnormal stock return for another reason. Several authors (see, e.g., Morris, 1996; Chen, Hong, and Stein, 2002; Duffie, Gârleanu, and Pedersen, 2002) have developed models that imply that the long-term underperformance of IPOs is due to heterogeneous expectations among investors about the firm's future cash flows and the fact that short-selling the shares of newly-public firms is costly. Chemmanur and Paeglis

[5] It is often observed that entrepreneurs wish to continue projects that investors would like to terminate (Admati and Pfleiderer, 1994; Cornelli and Yosha, 2003).

(2005) use the argument of Miller (1977) and argue that if the management of the company can reduce information asymmetry around the time of IPO, then there would be less dispersion across investors about firm valuation. This should reduce overvaluation of the firm at the time of the IPO, leading to superior post-IPO returns relative to other IPOs. Using the same reasoning, if inventor CEOs help reduce information uncertainty at the time of IPO, firms led by them would experience less overvaluation at the time of IPO relative to other IPOs and less negative abnormal returns during the post-IPO period. We note that one way to disentangle these two distinct channels is to examine the sign and magnitude of the abnormal returns for the inventor-led IPOs. The first explanation predicts positive abnormal stock returns, while the second simply predicts returns superior to those of non-inventor-led IPOs. We therefore examine the abnormal returns for inventor-led IPOs both in absolute terms and relative to those of non-inventor-led IPOs.

3. Data

A. Sample Selection

We extract a sample of all IPOs in the US between 1992 and 2010 from Securities Data Company (SDC) Global New Issues database. We choose 1992 as the start of this sample period because the information about the CEOs of the newly-listed firms, which we collect from several datasets such as Execucomp, Thomson Insider, Compustat Capital IQ, and BoardEx, is not easily available for earlier periods. The sample period ends in 2010 because the US Patent Inventor Database from Li et al. (2014), which we use to identify inventor status of the CEO, ends in 2010. In line with the prior literature, we exclude IPOs with an offer price of less than 5 dollars, financial institutions & utility firms, spin-offs from parent, depository shares, limited partnerships, and unit offerings. This yields 3,908 observations. We retain 2,286 of these firms that are labelled as 'high technology' by SDC Global New Issues database. We limit our analyses to technology firms, as in Islam and Zein (2020), because the bulk of innovation takes place in such firms and top executives with technical backgrounds are concentrated in these industries. After restricting the sample to IPOs with financial and stock price data in Compustat and Centre for Research in Security Prices (CRSP) we obtain 1,569 observations.

Next, we search for the names and identities of the CEOs for each of these IPOs. We start with the Execucomp database, which identifies CEO for each firm every year and provides

information on when the CEO took the role. If an IPO firm from our sample exists in the Execucomp dataset, we use the CEO employment period information and IPO date to identify the CEO at the IPO date. For the remaining IPOs, we manually obtain the names of the CEOs using Securities and Exchange Commission's (SEC) Electronic Data Gathering, Analysis, and Retrieval (EDGAR) website. The website provides filings of companies, including Form S-1, which is a general form for registration of securities under the Securities Act of 1933.

B. Classifying Inventor CEOs

After finding the CEO name at the IPO, we use the Inventor Database created by Li et al. (2014) to obtain the information on whether CEO is an inventor. The database eliminates ambiguities related to inventors and provides unique inventor and assignee firm IDs for each patent granted by United States Patents and Trademark Office. Using this database, we obtain the affiliations of inventors, co-inventors, addresses, and zip codes as well as the patents granted to these inventors over the years. Unfortunately, the identities of inventors cannot be automatically matched with those of the CEOs as the inventor database does not share a common identifier with any of the databases we use to collect the names of CEOs. Therefore, we follow a matching process akin to Islam and Zein (2020) and Bostan and Mian (2019) to match the names of the CEOs with those of the inventors. Specifically, the first and last names of inventors and the company names in the inventor database are matched with the CEO names in a step-wise procedure that starts with a fuzzy text-matching algorithm, which is followed by an examination of the biographies of the CEOs in the Capital IQ Professional Database and ends with searches in other sources including company web pages, Bloomberg, LinkedIn, DataStream, and more general Google searches. This elaborate process allows us to classify the CEOs of 1,458 high technology IPOs during 1992–2010 as inventors or non-inventors. Appendix A reports details of the data filtering process. Among these, 277 IPOs had inventor CEOs. We classify a CEO as an inventor if they had at least one patent registered in their name as an inventor at the time of the IPO.

Table 1 reports the distribution of the inventor-led IPOs. Panel A reports the distribution by year. The percentage of inventor-led IPOs varies across years and ranges from 0% to 35% with a mean of 19%. This percentage is almost the same as that reported by Islam and Zein (2020), which indicates that the preponderance of inventor CEOs among IPOs is no different from that

among the listed firms. Panel B reports the distribution by Fama–French 12-industries groups. As we examine high-tech IPOs, most of them belong to the Business Equipment and Healthcare industries. The former includes sectors such as Software, Semiconductors and related devices whereas the latter includes pharmaceutical preparations, surgical and medical instruments and apparatus. Panel C shows that out of the 277 CEOs identified as inventors, 62 had one patent, 39 had two patents, and the rest had more than two patents registered in their name at the time of IPO. Panel D reports the distribution of the future citations received for patents registered in the name of the inventor CEOs. The median number of citations is 158. We use this as a cut-off to identify high impact CEOs in a later section of our paper.

C. Outcome Variables

To study the effect of inventor CEOs on the success of an IPO we measure the success using three variables: IPO underpricing, post-IPO innovation, and post-IPO stock returns. We follow prior literature and measure underpricing as the percentage first-day return, calculated as the closing price on the first day of trading less the offer price, divided by the offer price. We assess firm-level innovation using several measures commonly used in the innovation literature. The two most common are the number of patents the firm generates and the total number of future citations, excluding self-citations, these patents receive (Hall, Jaffe, and Trajtenberg, 2005). We also examine the number of breakthrough patents the firms generates, which we alternatively define as those that fall among the top 1% or top 5% of the distribution of future citations in their technological class (Balsmeier, Fleming, and Manso, 2017).[6] We further study measures of *originality* and *generality* of patents (Trajtenberg, Henderson, and Jaffe, 1997; Hall, Jaffe, and Trajtenberg, 2001). The originality measure looks at the backward citations made by the firm in its patents. It is computed as one minus the Herfindahl index of the citations made by the patents that a firm applied for in a given year across two-digit technological classes. A high value indicates that the preceding patents cited belong to a wider set of technological classes. The generality measure reflects the forward citations received by the patents. It is computed as one minus the Herfindahl index of the citations received by the patents that a firm applied for in a given year across two-digit technological classes. A high value indicates that a firm's patents are cited by

[6] We detail these measures in Appendix B.

subsequent patents across a wide range of fields. The information on patents and citations for constructing the innovation measures comes from the 2010 version of the NBER patent database compiled by Kogan, Papanikolaou, Seru and Stoffman (2017).[7,8]

Finally, we analyze abnormal stock market returns during the three-year period following the IPO using the calendar-time portfolio strategy. We construct portfolios for each month based on the IPOs launched over the preceding 36 months, separately for inventor and non-inventor-led IPOs. We compute the returns on the portfolio for each month by equally weighting the returns on the individual stocks. This yields a monthly time series of returns for inventor- and non-inventor-led IPOs. We estimate the Fama–French three-factor model and include lagged values of the factors as in Ritter and Welch (2002). The intercepts of the model represent the monthly abnormal stock returns for the inventor and non-inventor-led IPOs.

D. Baseline Control Variables

Our multivariate regressions for IPO underpricing and post-IPO innovation include standard controls identified in prior literature. These include firm size measured as the natural log of book value of assets, firm age measured as the natural log of one plus the firm age, R&D intensity measured as R&D expenditure divided by total assets, a dummy variable to indicate whether the IPO is backed by a venture capitalist (VC), a dummy variable to indicate positive earnings per share, and an indicator for the Bubble period that is defined as the period between September 1998 and August 2000. Additionally, we include two controls that are particularly relevant in our context. First, we include an indicator variable for founder CEO because many of the inventor CEOs also tend to be founders and it becomes important to separate the effects of the two. Second, we include the natural log of one plus the total number of patents the firm has at the time of IPO. The inclusion of this variable is meant to control for the differences across IPOs in

[7] We download the data from https://sites.google.com/site/patentdataproject/Home.

[8] The number of citations received by the patents carry a similar well-known truncation problem. Because granted patents keep receiving citations many years into the future, the later it is in the sample period, the shorter the time period during which a patent can get citations. This results in fewer citations of the patents with later application dates. We correct this truncation problem using the commonly-adopted fixed-effect method described in Hall, Jaffe, and Trajtenberg (2001). Citations received for each patent are divided by the average number of citations received in the applied patent's technological field and in the application year to remove all the fixed effects of year and technological field.

their innovation intensities, which can affect information uncertainty surrounding an IPO, and hence its underpricing.

E. Summary Statistics

Table 2 reports the summary statistics of the key variables in our paper. The mean (median) underpricing is 34% (15%) during our sample period. It is known, however, that the underpricing experienced a large spike during the Internet bubble period of the late 1990s. Ritter and Welch (2002), for example, document that relative to the average underpricing of 19% for their overall sample period of 1980–2001, the average underpricing was 72% and 56% in the years 1999 and 2000, respectively. Therefore, we report the underpricing during the bubble and non-bubble periods separately. The numbers we report are very similar to those in Ritter and Welch (2002): the mean (median) underpricing is 18% (11%) in the non-bubble period and increases to 74% (50%) during the bubble period.

About 19% of the firms in our sample have inventor CEOs and 47% have founder CEOs at the time of IPO. As all firms in our sample are identified as "high-technology" by SDC dataset, they are highly R&D intensive. An average firm in our sample invests 26% of the book value of its assets in annual R&D expenditure. The average firm age is 9 years. These firms hold about four patents, on average, in their name at the time of their IPO. They are typically not profitable–only 36% report a positive earnings per share. This lack of profitability is not unique to the technology firms included in our sample. Loughran and McDonald (2013, Table 1), for instance, also report this ratio to be around 37% in their sample of IPOs.

4. Results

A. Univariate Comparison of the Characteristics of IPOs Led by Inventor versus Non-Inventor CEOs

We begin our analyses by comparing the characteristics of the IPOs led by inventor CEOs with those of IPOs led by non-inventor CEOs. Table 3 reports the mean and median of the key variables and also presents the univariate tests of the differences. At least three differences are discernable from Panel A, which reports the characteristics at the time of the IPO. First, the IPOs led by inventor CEOs seem significantly more innovation-intensive than those led by non-inventor CEOs. The average spending on R&D as a percentage of total assets is more than double for inventor-led IPOs than that of other IPOs, suggesting that they have a greater propensity to allocate resources to innovation. The mean (median) number of patents at the time of IPO is 9.34 (3) for the inventor-led firms compared to 3.18 (0) for the non-inventor-led firms. Interestingly, these differences between the innovation intensities of inventor- and non-inventor-led firms are significantly starker than those reported by Islam and Zein (2020) for the mature listed firms, suggesting that the personal involvement of CEOs in innovation might matter more for young start-up firms than for mature listed firms.

Second, inventor CEOs seem to be able to take their start-up firms to the stock market at an earlier stage in the firms' life cycle. Economists have long recognized that many early stage innovation projects fail to obtain external finance and are unable to go public due to high valuation uncertainty (Hall and Lerner, 2010; Hall, 2010). We note that the firms included in our sample are those that successfully managed to overcome this barrier and completed their IPOs successfully. Panel A in Table 2 shows that firms led by inventor CEOs are significantly smaller in size, somewhat younger, and considerably less profitable as compared to those led by non-inventor CEOs. These differences between the characteristics of investor- and non-inventor-led IPOs are consistent with the idea that inventor CEOs convey the value of their firm's innovation to outside financiers more credibly, which enables these CEOs to take smaller and less profitable firms to the market.

Finally, Panel A of Table 2 reveals that the average underpricing of IPOs led by inventor CEOs is smaller (28.55%) relative to those led by non-inventor CEOs (34.67%). This evidence is noteworthy when considering that inventor-led IPOs are more innovation intensive, smaller, younger, and less profitable—traits that are often associated with greater risk and uncertainty, and hence greater underpricing. For instance, Lowry, Officer and Schwert (2010) find that younger firms and technology firms experience greater underpricing than do other firms. Ritter and Welch

(2002) show that the underpricing is substantially higher for firms with negative earnings as compared to firms with positive earnings (though this effect is concentrated in the Internet bubble period of the late 1990s). The fact that the presence of inventor CEOs at the helm is associated with less underpricing despite the firms being apparently riskier is consistent with the hypothesis that inventor CEOs can reduce the uncertainty of their firm's innovation for external financiers, as mentioned previously. Interestingly, the difference in underpricing between inventor- and non-inventor-led IPOs disappear during the Internet bubble period, consistent with the notion that underpricing was driven more by investors' behavioral biases and less by the availability of information about firm fundamentals during this period (Ritter adn Welch, 2002).

Panel B of Table 3 reports differences in the post-IPO innovation performance of IPOs. Inventor-led IPOs fare better across almost all dimensions of innovation. They had a greater number of total patents and citations as well as a greater number of radical patents as compared to non-inventor-led IPOs. They also score better in terms of the generality and originality of their patents. Overall, the univariate results in Table 3 provide initial evidence that high technology IPOs led by inventor CEOs fare better both at the time of the IPO and during the post-IPO period. We formally test our hypotheses in multivariate settings as described in the following sections.

B. Inventor CEO's and IPO Underpricing

To formally assess the implications of the inventor status of CEOs on the underpricing of the IPOs we estimate ordinary least squares regressions in which we regress underpricing on the indicator variable for inventor CEOs and a set of controls. We also include industry fixed effects based on 49 Fama–French (1997) industries and year fixed effects in most specifications.[9] To account for error dependencies across industry and year, the standard errors are adjusted for two-dimensional clustering at the industry and year level.

Table 3 reports the results. The coefficient estimate on the inventor CEO indicator is negative and statistically significant in all specifications, suggesting that inventor-led IPOs are associated with less underpricing. The economic magnitude of the effect depends on the specification and sample. For the overall sample depicted in Column (1), which includes year and

[9] Because of the inclusion of fixed effects, we do not report intercepts of the regressions in most of our tables.

industry fixed effects, the coefficient estimate of -2.83 (*t*-statistic = 5.09) implies that IPOs led by inventor CEOs experience 2.8% less underpricing than do IPOs led by non-inventor CEOs. When we replace the year fixed effects in Column (2) with a dummy to account for the heightened underpricing during the Internet bubble period, the coefficient estimate increases to -3.91 (*t*-statistic = 3.17). This represents about 21% of the unconditional mean underpricing of the 18.4% reported for the non-bubble period (Table 2). The economic magnitude of the association between inventor CEOs and underpricing therefore appears meaningful.

If the negative relationship between inventor CEOs and IPOs' underpricing is due to the former's superior ability to resolve information asymmetry regarding the innovation capital of a firm, one would expect that the relationship is more pronounced for firms that have greater R&D intensity. This is because firms with high R&D intensity are likely to be those with greater innovation capital. To test this prediction, we use the median value of the ratio of the R&D expenditure to total assets to sort firms into high and low R&D intensity firms and estimate the underpricing regression separately for the two sub-samples. The last two columns of Table 4 report the results, which are starkly different. The negative relationship between the inventor CEO dummy and underpricing is driven by the high R&D intensity firms in our sample. Among these firms, the relationship is very pronounced—the estimated coefficient of the inventor CEO dummy implies that IPOs led by inventor CEOs experience 8.7% less underpricing than IPOs led by non-inventor CEOs.[10]

Among the control variables, firm age seems to be a key driver of the underpricing in our sample, with smaller firms experiencing considerably larger underpricing. This is consistent with the results reported in prior literature such as Chemmanur and Paeglis (2005) and Lowry, Officer and Schwert (2010). We also find that the two variables we use to depict the innovation intensity of firms—R&D intensity and number of firm patents—have positive and somewhat significant coefficients, which is consistent with the finding in Lowry, Officer and Schwert (2010) that technology stocks experience greater underpricing.[11] Firm age and innovation intensity can both

[10] It is worth noting that our evidnce is based on firms that successfully manage to complete their IPO. Start-up firms that fail to reach the IPO stage are not included in our analyses. We therefore do not know how successful inventor CEOs are in guiding their firms' from inception to the IPO.

[11] The coefficient estimate on R&D intensity appears unusually large for low R&D intensity firms in Column (4), Table 4. This is because firms included in this sample generally have close to zero R&D intensity, with mean of

act as proxies for the difficulty in the valuation and the information asymmetry surrounding an IPO, and their relationships as we report them are consistent with the theoretical models in which information asymmetry drives the underpricing.

We also examine whether inventor CEOs that are 'serial innovation entrepreneurs' are different from other inventor CEOs that only possess patents in the IPO firm. We split the inventor CEO dummy into two: One signifying inventor CEOs that possess at least one prior patent in another firm besides holding patent(s) in the IPO firm, and the other depicting inventor CEOs that hold patent(s) only in the IPO firm. In untabulated results, we find no discernable differences between the coefficient estimates on the two inventor CEO dummies in the underpricing regressions. This suggests that our result in Table 4 are driven by inventor CEOs' knowledge about firm-specific innovation and not by general experience with innovation.[12]

C. Inventor CEO's and Post-IPO Firm Innovation

Arguably, the aspect of a firm's performance most directly influenced by the personal hands-on innovation experience of a CEO is the firm's innovation activities. Islam and Zein (2020) demonstrate that the presence of inventor CEOs at the helm increases the innovation productivity of listed firms in the US. It is therefore natural to ask whether the innovation-enhancing impact of inventor CEOs also holds for young, newly-listed firms during their early transition years. The superior ability to evaluate and execute investments in innovation can be especially beneficial during this period as the firms invest large sums of new capital raised through the public offering.

To examine this, we regress measures of the innovation success of newly-listed firms during the three-year post-IPO period on the indicator variable for inventor CEO and a set of controls. As noted previously, we measure the success of a firm's innovation across several dimensions, namely the number of patents it generates, the number of future citations those patents receive, the number of breakthrough patents, and the generality and originality of the patents. We

0.05. In untabulated results, we find that when we remove R&D intensity as a control in Columns 4 and 5, our results remain qualitatively similar.

[12] We also experiment with splitting inventor CEO dummy into two based on whether the IPO is backed by a VC or not. We find that the underpricing is similar for inventor CEOs that are backed by a VC and those that are not. This shows that our results are not driven by "the certification effect" of certain inventor CEOs by venture capitalists.

use the average of these variables over the three-year post-IPO period because innovation is a long-term process, and a newly-listed firm's success or failure may not be appropriately judged based on data of a smaller timeframe.[13] We also include the three-year average of the respective innovation variables over the pre-IPO period as an additional control. Therefore, we investigate the change in innovation output of the newly-listed firm following the IPO and how this change is related to the presence of an inventor CEO at the top. It also helps to account for the firm fixed effects that might influence firm innovation output during the post-IPO period.

Table 5 reports the results of the analysis. The coefficient estimates on the inventor CEO dummy are positive across all measures of innovation and statistically significant for most. The firms led by inventor CEOs generate a larger number of patents as well as citations for their patents. The economic magnitude of these effects is large. Firms led by inventor CEOs produce 1.2 more patents and 28.2 more citations as compared to firms led by non-inventor CEOs. The magnitudes of these coefficients appear economically meaningful when compared to the unconditional mean values of 1.98 and 84.7 at the time of IPO, respectively, as reported in Panel B of Table 2. Inventor CEOs are also more likely to spur ground-breaking or disruptive innovations, as shown by their firms' greater propensity to produce patents that are cited in the 99th and 95th percentile of the citation distribution within their technology class-year. Furthermore, the patents these firms generate are more original; in that the preceding patents they cite belong to a wider set of technological classes. In all regressions, the lagged values of the dependent variable are highly significant, which indicates the importance of controlling for past innovation in predicting future firm innovation. Overall, Table 5 provides evidence that newly-listed firms led by inventor CEOs experience considerably better innovation outcomes in the three years following the IPO relative to firms led by non-inventor CEOs.

D. Inventor CEO's and Post-IPO Stock Returns

If stock market does not fully understand the positive relationship between inventor CEOs and the future firm innovation of newly-listed firms at the time of the IPO, one would expect that IPOs led by inventor CEOs experience superior abnormal stock returns during the three-year post-

[13] Even the process of obtaining a patent itself takes more than two years on average (Hall, Jaffe, and Trajtenberg, 2001), as noted previously.

IPO period. The measurement of long-term returns for IPOs, however, is fraught with problems due to overlapping returns and because most IPO firms tend to be small-growth firms with risk exposures different from that of a typically listed firm (Ritter and Welch, 2002). We therefore adopt the calendar time portfolio approach and estimate abnormal returns by using the Fama and French (1993) three factor regressions. Following Ritter and Welch (2002) and Chemmanur and Paeglis (2005), we include the lagged values of the factors in the regressions. The estimates of intercepts are measures of monthly abnormal returns, with negative intercepts indicating underperformance and positive ones indicating outperformance.

We form calendar-time portfolios separately for IPOs led by inventor and non-inventor CEOs and compute monthly abnormal returns for each. We also examine the difference between the abnormal returns of the two portfolios. Our return evaluation period is February 1992 to June 2013. We choose February 1992 as the starting point because this is the first month following the first two inventor-led IPOs in our sample were launched in January 1992. We choose June 2013 as the upper limit of this timeframe because it covers the three-year period following the last inventor-led IPO in June 2010. As the number of stocks in the portfolio of inventor-led IPOs varies considerably over time, ranging from 1 to 79 per month, with the beginning and ending months of the sample containing very few stocks, we follow Chemmanur and Paeglis (2005) and estimate the regressions using weighted least squares with the weights based on the number of stocks in the monthly portfolio.

Table 6 reports the results of the analysis. The IPOs led by inventor CEOs experience abnormal stock returns of 0.83% per month (*t*-statistic = 2.23) in the three-year period following the IPO. This translates into 10.43% return on an annualized basis. This level of abnormal returns is striking, especially given the finding of negative or close-to-zero abnormal stock returns for an average IPO in the traditional IPO literature (Ritter and Welch, 2002). For the IPOs led by non-inventor CEOs, the average abnormal stock return is a statistically insignificant and 0.11% per month, which is more similar to the returns reported for IPOs in prior literature. The difference

between the returns of inventor- and non-inventor-led IPOs is 0.68% per month (*t*-statistic = 2.15).[14]

The evidence that investors who buy IPOs of inventor-led technology firms experience economically large abnormal stock returns in the three-year period following the month of the IPO is more consistent with the idea that the stock market fails to fully appreciate the positive relationship between inventor CEOs and future firm innovation in the post-IPO period. The evidence seems inconsistent with the alternative explanation adapted from Chemmanur and Paeglis (2005). According to this explanation, lower dispersion of opinions, and hence, lower overvaluation at the time of the IPO cause investors to earn higher abnormal return for inventor-led IPOs relative to non-inventor-led IPOs. While this can explain the overperformance of inventor-led IPOs *relative to* non-inventor-led IPOs in the post-IPO period, it cannot explain their large positive abnormal returns.[15]

The coefficient estimates on the Fama–French three factors in Table 6 are also informative. For the portfolio containing inventor-led IPOs, the coefficient estimate on the *SML* factor (i.e., small minus large factor) is positive, consistent with IPO stocks being smaller in size than those typically listed on the exchange (Ritter and Welch, 2002). Interestingly, the coefficient estimate is also larger than that for the portfolio containing non-inventor-led IPOs, consistent with the evidence in Table 3 that inventor-led IPOs are smaller in size than non-inventor-led IPOs. Likewise, the coefficient estimate on the *HML* factor (high book-to-market minus low-book-to-market) is negative, consistent with a tilt to growth among IPO firms when compared to an average listed firm (Ritter and Welch, 2002).

[14] Because we estimate Fama–French three factor regressions in Table 6 using weighted least squares, the coefficient estimates in the last column, which reports the returns on a long—short portfolio that takes a long position in inventor-led IPOs and short position in non-inventor-led IPOs, are not simply the difference between the respective estimates in the first two columns.

[15] Yet another explanation for a positive relation between a CEO characteristic and future stock return, which does not rely on market inefficiency, is suggested by Lilienfeld-Toal and Ruenzi (2014). They argue that market prices cannot fully reflect the future effort of a CEO, because she could otherwise profit from the price increase right away by selling her stocks without having to carry out value-increasing effort and bearing the associated personal costs. We belive that this explanation is less relevant in our context not only because many of the inventor CEOs in our sample are also founders who typically remain with their firms for long periods of time, but also because of the constraints such as the post-IPO lock-up period that limit the ability of a CEO to dispose of her stake in the period following the IPO.

5. Addressing Endogeneity Concerns

A. Results for Founder-Only Sample

A CEO may be selected due to the fit between the individual and job requirements. A technology firm that is planning to go public may prefer to appoint an inventor CEO believing that the CEO would be better at managing the firm's transition from private to public entity. Our previous results for underpricing and post-IPO firm innovation may be therefore driven by such optimal CEO-firm matching. To extricate the confounding effect of matching and focus on the causal interpretation, we utilize the founder-status of CEOs. We divide our sample into firms led by founder CEOs and those led by non-founder CEOs and examine whether within the sub-sample of firms with founder CEOs, the IPOs led by inventor CEOs are associated with superior IPO outcomes. The concern that a CEO with certain characteristics is hired around the IPO time to make the firm's public listing successful should be less of a concern for this sub-sample.

Table 7 replicates our previous results for underpricing and innovation for the founder and non-founder samples separately. The regressions include the same controls as before except for the indicator variable for founder CEO which is now dropped. We first focus on the results for the sample of founder CEOs. Panel A reports the estimates of the underpricing regression. Though the coefficient estimate on the indicator variable for inventor CEO is slightly weaker than that reported previously for the overall sample (in Table 4, Column 1), it remains significant at 1.96 (*t*-statistic = 2.03). Panel B explores the effect of inventor CEOs on post-IPO firm innovation. The coefficients on the inventor CEO variable for the founder-only sample are comparable to those reported previously (in Table 5). Inventor CEOs continue to exhibit a strong positive relationship with the number of total patents, number of radical patents, and originality of the patents. Overall, the results for the founder CEO sample are in line with those reported previously, providing support to the causal interpretation of our results.

Table 7 also reports the results for the non-founder sample. Interestingly, these results are generally stronger than those for the founder sample. This is consistent with our conjecture that in the non-founder sample, one expects both the causal as well as the selection effect to be at work. It appears as if some technology firms optimally replace non-inventor CEOs with inventor CEOs that are better at managing the firm's IPO. Such optimal selection seems to be especially helpful

for firms in reducing underpricing at the time of IPO, as reflected in much higher coefficient estimate on the indicator variable for inventor CEO in Panel A for founders than that for non-founders. The results in Panel B suggest that the beneficial effect of the selection is less pronounced for post-IPO innovation. Even though the coefficient estimates on the indicator variable for inventor CEO are larger for non-founders than those for founders, the differences are not as large as in Panel A.

B. Matching Estimator Analysis

We report significant differences between the inventor- and non-inventor led IPOs in size, R&D intensity, and profitability in Table 3. These differences raise a concern that our baseline results in Section 4, which are based on linear regressions, may be biased. The bias could have resulted from possible non-linearity in the relationship between the controls and dependent variables in those regressions or from a poor distributional overlap between the treated and non-treated firms across one or more of the controls.

To address this shortcoming, we conduct our analyses based on a sample of treated and control firms that are similar with regards to the control variables and compute the Abadie and Imbens (2006, 2011) matching estimator. We first estimate propensity score, which is the conditional probability of an IPO being led by an inventor CEO given a firm's pre-IPO characteristics, for all the IPOs by estimating a probit regression. In this regression, we include all seven firm and CEO characteristics that we employ as controls in our underpricing regression in Table 4. Based on the propensity score, we match each treated IPO with three non-treated control IPOs and permit matching with replacement.[16] We then estimate the average effect of the treatment on the treated (*ATT*) in order to evaluate the effect of inventor CEOs on the IPO outcome variables.

Panel A of Table 8 reports the means of the key characteristics of the treated and control firms in our matched sample. None of the characteristics' means are now different in terms of statistical significance between treated and control IPOs according to the two-sided *t*-tests. This confirms that the matching procedure results in the treated and control firms are comparable along

[16] We obtain qualitatively similar results when we match each treated IPO with one control IPO.

the observables, thereby rendering the non-treated IPOs as reasonable counterfactual observations for the treated IPOs.

Panel B of Table 8 reports the matching estimator results. Strikingly, the difference in underpricing based on the matching estimator is larger than that reported in Table 4. For treated firms—those with inventor CEOs—the average underpricing is 28%. The corresponding number for the control firms is 37%. The difference of 9.3% (*t*-statistic = 2.13) indicates that the underpricing is considerably higher among the control firms relative to the treated firms. Stronger results for the matching estimators are not surprising. As mentioned previously, the inventor-led IPOs are smaller, less profitable, and more R&D intensive, which are characteristics that are typically associated with greater underpricing. Matching estimator allows these characteristics to have a non-linear relationship with underpricing, and thus provides a better estimate of the true relationship between investor CEOs and underpricing.

Panel B of Table 8 reports differences in measures of post-IPO innovation across inventor- and non-inventor-led IPOs based on matching estimator. When conducting this analysis, we repeat the propensity-score-based matching for each innovation measure, specifically adding the lagged value of the respective innovation measure in the computation of propensity score. This ensures that the control firms are similar to the treated firms in terms of the respective innovation measure at the time of the IPO. The average treatment effects for the treated (*ATTs*) reported in Table 8 again indicate generally stronger effects of inventor CEOs on post-IPO innovation than those reported in the linear regression results of Table 5. For example, the difference between the number of patents for inventor and non-inventor-led IPOs is now 1.6 as opposed to 1.2 reported in Table 5. The difference between the number of citations for inventor and non-inventor-led IPOs is 85 as opposed to 28 in Table 5. Thus, the propensity score matched sample in Table 8 reveals a stronger influence of inventor CEO on underpricing and post-IPO innovation.

C. High Impact Inventor CEOs

Thus far, our analysis employed a dummy variable to indicate an inventor CEO. The variable takes the value of one as long as CEOs have at least one patent registered in their name at the time of firms' IPO and does not differentiate amongst inventor CEOs. Yet, as Table 1 indicates, inventor CEOs do exhibit heterogeneity in terms of both the number of patents registered in their

name and the future citations these patents receive. In this section, we explore if the associations we document previously are stronger when the innovation an inventor CEO is involved with is more impactful. To identify the impact of the innovation of an inventor CEO we use the forward citations data from KPSS and define high impact inventor CEOs as those whose patents receive more than the median number of citations. Conversely, those inventor CEOs whose patents receive less than the median number of citations are labelled as low impact inventor CEOs. As reported in Table 1, the median number of technology class-year adjusted citations for inventor CEOs is 158 in our sample.

Panels A and B in Table 9 replicate our earlier results for underpricing and post-IPO innovation, respectively, after replacing the inventor CEO indicator variable with two separate indicator variables for high and low impact inventor CEOs. In both panels, the coefficient estimates on the high impact inventor CEO dummy are economically stronger and statistically more significant than the corresponding estimates on the low impact inventor CEO dummy. In Panel A, the coefficient estimates on high and low impact inventor CEO are 6.31 (t-statistic = 1.89) and 0.47 (t-statistic = 0.13), respectively. The coefficient estimate on the indicator variable for the high impact inventor CEO implies that underpricing is 6.3% less for IPOs led by high impact inventor CEOs relative to those led by non-inventor CEOs. The magnitude of this effect is more than double as compared to that reported for all inventor CEOs in Column (1) of Table 4. The statistical significance, however, of the coefficient estimate is lower because of the fewer observations. Similar conclusion can be drawn from the last column in Panel A that reports the underpricing regression for the high R&D firms. Panel B reports the regression estimates for post-IPO firm innovation. The estimated coefficients indicate that the influence of high impact inventor CEOs is more pronounced than that for the low impact inventor CEOs for firm innovation. Overall, the results in Table 9 suggest that the relationships we document earlier are stronger and primarily driven by inventor CEOs that possess higher quality innovation experience.

6. Conclusion

In this paper we investigate whether a CEO's hands-on innovation experience as an inventor endows them with unique capabilities in managing the transition of their firms from private to public entities. Our findings indicate a positive association between inventor CEOs and

three measures of success for an IPO. First, IPOs led by inventor CEOs experience lower levels of underpricing and this effect is especially pronounced among more R&D intensive firms. We interpret this as evidence consistent with the superior ability of inventor CEOs to communicate the value of their firm's innovation to investors. Second, IPOs led by inventor CEOs produce significantly better innovation outputs for a range of alternative innovation measures in the three-year period following the IPO. Third, inventor-led IPOs experience large positive abnormal stock returns in the post-IPO period, consistent with the idea that the stock market does not fully understand the positive relationship between inventor CEOs and future firm innovation. Our results remain robust in the sub-sample of firms that are led by founders and in matched estimator analyses. Overall, our results paint a consistent picture of the positive influence of CEOs' hands-on innovation experience in the success of the technology firms' IPOs.

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Table 1
Sample Distribution of Inventor CEOs

Panels A and B of this table provide a breakdown of the number of inventor CEOs, non-inventor CEOs, and the percentages of inventor CEOs, by year and industry groups, respectively. The sample is based on high-technology IPOs in the US during 1992–2010. Panels C and D report information about the strength of the innovation experience of inventor CEOs.

Panel A: Distribution of Inventor- and Non-Inventor-Led Technology IPOs by Year

Year	# of IPOs	IPOs with Non-Inventor CEO	IPOs with Inventor CEO	Percent of IPOs with Inventor CEO
1992	66	53	13	20%
1993	84	70	14	17%
1994	92	76	16	17%
1995	150	125	25	17%
1996	124	98	26	21%
1997	113	86	27	24%
1998	70	64	6	9%
1999	227	195	32	14%
2000	188	151	37	20%
2001	24	19	5	21%
2002	24	19	5	21%
2003	24	20	4	17%
2004	71	46	25	35%
2005	49	38	11	22%
2006	50	41	9	18%
2007	73	55	18	25%
2008	4	4	0	0%
2009	6	6	0	0%
2010	19	15	4	21%
Total	1,458	1,181	277	19%

Panel B: Distribution of Inventor- and Non-Inventor-Led Technology IPOs by Industry

Fama–French 12 Industries	Total IPOs	IPOs with Non-Inventor CEO	IPOs with Inventor CEO	Percent of IPOs with Inventor CEO
Business Equipment	840	703	137	16%
Healthcare	344	241	103	30%
Communication	83	79	4	5%
Wholesale and Retail	40	38	2	5%
Manufacturing	20	11	9	45%
Consumer Non-Durables	7	6	1	14%
Consumer Durables	5	5	0	0%
Chemicals	2	1	1	50%
Other	117	97	20	17%
Total	1,458	1,181	277	19%

Panel C: Distribution of the Cumulative Number of Patents Received by Inventor CEOs at the time of IPO

Cumulative # of patents at the time of IPO	# of CEOs
1	62
2	39
3–10	93
> 10	83
Total	277

Panel D: Distribution of the Number of Future Citations Received by Inventor CEOs for their Patents at the time of IPO

Cumulative # of future citations for patents at the time of IPO	# of CEOs
1–30	52
31–100	63
101–400	94
> 400	68
Total	277

Table 2
Summary Statistics

This table presents summary statistics for select variables used in this study. All variables have been winsorized. Their definitions are provided in Appendix B. *Inventor CEO*, *Founder CEO*, *VC-Backed*, and *Positive EPS* are all indicator variables. The sample is based on high-technology IPOs in the US during 1992–2010.

Variables	Mean	Median	St. Dev.	Min.	Max.
Panel A: Firm and CEO Characteristics at the time of IPO					
Underpricing	33.5%	15.3%	55.3%	-32.8%	294.4%
Underpricing—Bubble period	74.2%	49.6%	83.1%	-32.8%	294.4%
Underpricing—Excluding Bubble period	18.4%	10.8%	28.3%	-32.8%	294.4%
Inventor CEO	0.19	0	0.39	0	1
Founder CEO	0.47	0	0.5	0	1
Total Assets (in million $)	73.54	22.25	184.11	0.48	1427.65
R&D/Total Assets	26.2%	17.1%	32.3%	0.0%	179.3%
Firm Age	9.23	7	8.74	0	60
Firm Patents	4.35	0	9.72	0	61
VC-Backed	0.68	1	0.47	0	1
Positive EPS	0.36	0	0.48	0	1
ROA	-26.5%	-3.9%	70.7%	-388.4%	62.9%
Panel B: Post-IPO Innovation (Averaged Over Three Years)					
Number of Patents	1.98	0	6.4	0	85.01
Number of Citations	84.7	0	290.6	0	3,122.0
Number of Top 1% Patents	0.06	0	0.29	0	4
Number of Top 5% Patents	0.22	0	0.89	0	12
Generality	0.21	0	0.29	0	0.89
Originality	0.16	0	0.26	0	0.85

Table 3
Univariate Tests for Differences Across Inventor and Non-Inventor led IPOs

This table reports univariate tests of the differences in select variables across inventor and non-inventor led IPOs. The *t*-statistics (Wilcoxon *z*-statistics) are used to test for differences between the means (medians). *Inventor CEO*, *Founder CEO*, *VC-Backed* and *Positive EPS* are all indicator variables. Detailed variable definitions are provided in Appendix A2. The sample is based on high-technology IPOs in the US during 1992–2010. *, **, and *** denote significance level at the 10%, 5%, and 1% level, respectively.

	Mean			Median		
Variables	IPOs with Non-Inventor CEO	IPOs with Inventor CEO	*t*-statistic for difference	IPOs with Non-Inventor CEO	IPOs with Inventor CEO	Wilcoxon *z*-statistic for difference
Panel A: Firm and CEO Characteristics at the time of IPO						
Underpricing	34.7%	28.6%	-1.66*	15.7%	13.2%	-1.90*
Underpricing - Bubble Period	74.2%	74.1%	-0.01	50.0%	41.0%	0.11
Underpricing - Excluding Bubble Period	19.3%	14.9%	-2.06**	11.4%	9.1%	-2.16**
Inventor CEO	0	1				
Founder CEO	0.41	0.73	9.89***	0	1	9.58***
Total Assets (in million $)	81.74	38.59	-3.52***	22.66	18.66	-3.28***
R&D/Total Assets	23.3%	38.3%	7.04***	15.4%	24.1%	7.82***
Firm Age	9.44	8.32	-1.93*	7	7	-0.54
Firm Patents	3.18	9.34	9.79***	0	3	12.09***
VC Backed	0.67	0.74	2.37**	1	1	2.37**
Positive EPS	0.37	0.31	-1.91*	0	0	-1.91*
ROA	-22.9%	-41.5%	-3.94***	-0.01%	-21.1%	-3.66***
Panel B: Post-IPO Innovation (Averaged Over Three Years)						
Number of Patent	1.98	5.57	7.59***	0	2	11.92***
Number of Citations	84.7	197.9	5.30***	0	52.3	10.99***
Number of Top 1% Patents	0.06	0.13	3.54***	0	0	3.60***
Number of Top 5% Patents	0.22	0.58	5.34***	0	0	7.15***
Generality	10.21	0.42	11.15***	0	0.51	10.82***
Originality	0.16	0.28	6.68***	0	0.22	8.10***

Table 4
Inventor CEOs and IPO Underpricing

This table reports the relationship between inventor CEOs and IPO underpricing. The sample includes high technology U.S. IPOs from 1992 to 2010. The dependent variable in all regressions is the percentage first-day return, calculated as the closing price on the first day of trading less the offer price, divided by the offer price. For the last two columns, the sample is divided into two categories based on the median value of R&D divided by Total Assets. Year fixed effects are based on the IPO year and industry fixed effects are based on Fama–French 48-industry classification. The *t*-statistics (in parentheses) are computed using heteroskedasticity-consistent standard errors that are corrected for clustering across year and industry. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

	Dependent Variable = Underpricing				
	Full Sample with Year FE	Full Sample with Bubble Period Dummy	Excluding Bubble Period	Low R&D Intensity Sample	High R&D Intensity Sample
Explanatory Variables	(1)	(2)	(3)	(4)	(5)
Inventor CEO	-2.83***	-3.91***	-3.19***	1.13	-8.67**
	(-5.09)	(-3.17)	(-3.74)	(0.17)	(-2.23)
Founder CEO	0.65*	0.68	3.55**	-1.05**	4.38***
	(1.95)	(0.50)	(2.46)	(-2.05)	(3.48)
ln(Total Assets)	3.28	1.98	1.05	2.82	8.90**
	(1.59)	(1.19)	(1.07)	(1.60)	(2.18)
R&D/Total Assets	0.022**	0.017*	0.012***	115.51***	3.03***
	(2.38)	(1.90)	(3.59)	(2.70)	(2.87)
ln(Age)	-7.24***	-8.35***	-4.85***	-6.47***	-11.26***
	(-4.49)	(-4.82)	(-2.73)	(-2.74)	(-4.67)
Firm Patents	4.53**	4.63**	3.19*	6.06***	1.06
	(2.23)	(2.20)	(1.94)	(2.62)	(0.78)
VC Backed	8.45*	7.33	0.88	5.45	3.62
	(1.70)	(1.49)	(0.47)	(1.39)	(1.02)
Positive EPS	-0.34	1.08	2.68**	-1.26	-3.97*
	(-0.27)	(1.34)	(1.98)	(-0.53)	(-1.75)
Bubble Period		47.38***			
		(8.14)			

Observations	1,458	1,458	1,064	726	732
R-squared	0.268	0.264	0.163	0.266	0.343
Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	No	Yes	Yes	Yes

Table 5
Inventor CEOs and Post-IPO Innovation

The table reports the estimates from several regressions that examine the relationship between inventor CEOs and post-IPO firm innovation. The dependent variable is firm's innovation output averaged over the three years following the IPO. We include the lagged values (averaged over the three years preceding the IPO year) of the dependent variables in all the regressions. Year fixed effects based on the IPO year and industry fixed effects are based on Fama–French 48-industry classification. The *t*-statistics (in parentheses) are computed using heteroskedasticity-consistent standard errors that are corrected for clustering across year and industry. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

	Dependent Variable = Post-IPO Innovation					
	Patents	Citations	Top 1% Patents	Top 5% Patents	Generality	Originality
Explanatory Variables	(1)	(2)	(3)	(4)	(5)	(6)
Inventor CEO	1.240**	28.205	0.051*	0.123***	0.044	0.096***
	(2.47)	(1.66)	(1.92)	(3.37)	(1.71)	(3.02)
Founder CEO	0.194	12.478	-0.007	0.046	0.015**	0.024**
	(0.48)	(0.83)	(-0.57)	(0.77)	(2.56)	(2.24)
ln(Total Assets)	0.588***	17.029***	0.009	0.049**	-0.004**	-0.004
	(3.07)	(3.32)	(1.16)	(2.22)	(-2.32)	(-1.30)
R&D/Total Assets	0.001	0.022	0.000	0.000	0.000	-0.000
	(0.78)	(0.46)	(0.08)	(0.79)	(0.29)	(-0.10)
ln(Age)	-0.299	8.269	0.003	0.018	0.003	0.009
	(-1.41)	(0.72)	(0.25)	(0.45)	(0.36)	(1.19)
VC Backed	0.242	-6.054	-0.006	-0.001	0.043***	0.064***
	(0.82)	(-0.32)	(-0.28)	(-0.02)	(4.32)	(5.97)
Positive EPS	0.261	-26.093	-0.026	-0.067	-0.014	0.014
	(0.52)	(-1.05)	(-1.49)	(-1.20)	(-1.40)	(0.84)
Pre-IPO Patent	1.430***					
	(5.25)					
Pre-IPO Citations		0.663***				
		(9.16)				
Pre-IPO Top 1 Patent			0.403***			
			(4.24)			
Pre-IPO Top 5 Patent				0.685***		
				(7.52)		
Pre-IPO Generality					0.315***	
					(10.11)	
Pre-IPO Originality						0.385***
						(17.35)

Constant	-0.846	-24.089	0.015	-0.074	0.090***	0.085***
	(-1.53)	(-0.90)	(0.85)	(-0.67)	(3.29)	(4.52)
Observations	1,458	1,458	1,458	1,458	1,458	1,458
R-squared	0.331	0.402	0.202	0.307	0.398	0.338
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 6
Inventor CEOs and Post-IPO Abnormal Stock Returns: Fama–French Time Series Regressions

This table reports the estimates of abnormal stock returns during the 3-year post-IPO period for firms led by inventor and non-inventor CEOs. Standard calendar time portfolio approach is followed with intercepts from Fama–French factor model regressions depicting the abnormal returns. All regressions are estimated using 257 monthly observations for the period February 1992 to June 2013. The dependent variable in the first (second) column is the equally weighted monthly percentage return on a portfolio of IPO firms led by inventor CEOs (non-inventor CEOs) that have gone public during the prior 36 months. The dependent variable in the last column is the difference between the monthly returns of equally-weighted portfolios of inventor- and non-inventor-led IPOs. The regressions are estimated using weighted least squares, with the weights based on the number of IPO firms in the monthly portfolio. $(R_m - R_f)$ is the realization of the market risk premium. SMB_t is the return on a portfolio of small stocks minus the return on a portfolio of big stocks. HML_t is the return on a portfolio of high book-to-market stocks minus the return on a portfolio of low book-to-market stocks. The factor returns are supplied by Kenneth French. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

Variables	Inventor CEOs	Non-Inventor CEOs	Difference (Inventor – Non-Inventor)
$(R_m - R_f)_t$	1.17***	1.33***	-0.37***
	(14.99)	(19.62)	(-4.46)
$(R_m - R_f)_{t-1}$	0.34***	0.29***	-0.06
	(4.41)	(4.35)	(-0.65)
SMB_t	1.51***	1.04***	0.43***
	(16.50)	(9.75)	(6.43)
SMB_{t-1}	0.09	0.11	-0.09
	(1.04)	(1.04)	(-1.52)
HML_t	-0.99***	-0.73***	0.12
	(-9.57)	(-6.91)	(1.00)
HML_{t-1}	-0.05	-0.21**	-0.23**
	(-0.45)	(-2.11)	(-2.20)
Intercept	0.83**	0.11	0.68**
	(2.23)	(0.42)	(2.15)
# of Months	257	257	257
Avg. No. of Stocks Per Month	37	151	188
R-squared	0.89	0.76	0.77

Table 7
Sub-Sample Analyses for Founder versus Non-Founder CEOs

This table re-estimates the previous results for founder and non-founder CEO sub-samples separately. In panel A, the dependent variable is the underpricing in percent. In Panel B, the dependent variables are various measures of post-IPO innovation. The key explanatory variable in both panels is *Inventor CEO*. Both panels include the same set of controls as used in the corresponding analyses earlier. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

Panel A: Inventor CEOs and Underpricing

	Dependent variable = Underpricing	
Variables	Founder CEO Sample	Non-Founder CEO Sample
Inventor CEO	-1.96**	-7.30**
	(-2.03)	(-2.33)
Controls	Yes	Yes
Observations	681	777
R-squared	0.248	0.312
Industry FE	Yes	Yes
Year FE	Yes	Yes

Panel B: Inventor CEOs and Post-IPO Innovation

	Founder CEO Sample				Non-Founder CEO Sample			
	Dependent Variable = Post-IPO innovation measures				Dependent Variable = Post-IPO innovation measures			
Variables	Patents	Citations	Top 5% Patents	Originality	Patents	Citations	Top 5% Patents	Originality
Inventor CEO	1.23***	27.84	0.15***	0.09**	1.41	40.18	0.19	0.10**
	(6.30)	(1.36)	(5.20)	(2.15)	(1.26)	(0.88)	(1.25)	(2.31)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	675	675	675	675	774	774	774	774
R-squared	0.31	0.40	0.24	0.34	0.38	0.43	0.43	0.35
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 8
Inventor CEOs and IPO Outcomes: Matching Estimator Analysis

This table presents estimates based on a matching estimator analysis. We first estimate propensity score using a probit regression for the probability of firms appointing an inventor CEO and include the same firm and CEO characteristics that we employ as controls in our earlier regressions. Based on the propensity score, we then match each treated IPO with three non-treated IPOs permitting matching with replacement. Panel A reports the differences between the means of the key firm characteristics for the treated and the control samples. Panel B then uses this matched sample to re-examine the average underpricing and post-IPO innovation across IPOs led by inventors (Treated sample) and non-inventors (Control sample). *ATT* is the Abadie and Imbens (2006, 2011) bias corrected average treatment effect on the treated matching estimator. ∗, ∗∗, and ∗∗∗ denote significance at the 10%, 5%, and 1% level, respectively.

Panel A: Comparison of Means of Key Covariates Across Treated and Control IPOs in the Matched Sample

	Mean		Difference between Means	
Variable	Treated	Control	*t*-statistic	*p*-value
Founder CEO	0.72	0.68	1.05	0.29
ln(Total Assets)	2.87	2.94	-0.58	0.56
R&D/Total Assets	0.38	0.37	0.26	0.79
ln(Age)	2.05	2.09	-0.84	0.4
Firm Patents	1.52	1.61	-0.83	0.41
VC Backed	0.74	0.76	-0.65	0.52
Positive EPS	0.31	0.32	-0.09	0.94

Panel B: Average IPO Outcomes for Treated versus Control IPOs

	Average IPO Outcome		Matching Estimator (*ATT*)	
	Treated	Controls	Difference	*t*-statistic
Underpricing	27.7%	37.0%	9.3% **	-2.13
Patents	4.51	2.88	1.63 **	2.34
Citations	189.39	104.52	84.87 ***	2.72
Top 1% Patents	0.14	0.08	0.07 *	1.72
Top 5% Patents	0.55	0.44	0.12	0.9
Generality	0.27	0.21	0.06 **	2.14
Originality	0.414	0.297	0.117 ***	4.25

Table 9
Sub-Sample Analyses for High Impact Inventor CEOs

This table re-estimates previous regressions using separate indicator variables for high and low impact inventor CEOs. Those inventor CEOs that have above-median (below-median) citations for the patents they own are labeled as high-impact (low-impact) inventor CEOs. In panel A, the dependent variable is the underpricing in percent. In Panel B, the dependent variables are various measures of post-IPO innovation. Both panels include the same set of controls used in the corresponding analyses previously. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

Panel A: High Impact Inventor CEOs and Underpricing

	Dependent Variable = Underpricing	
Explanatory Variables	Full Sample	High R&D Firms
High Impact Inventor CEO	-6.31*	-11.18
	(-1.89)	(-1.31)
Low Impact CEO	0.47	-6.08***
	(0.13)	(-2.74)
Controls	Yes	Yes
Observations	1,320	732
R-squared	0.27	0.34
Industry FE	Yes	Yes
Year FE	Yes	Yes

Panel B: High Impact Inventor CEOs and Post-IPO Innovation

	Dependent Variable = Post-IPO Innovation measures			
Variables	Patents	Citations	Top 5 Patents	Originality
High Impact CEO	2.19***	49.64*	0.26***	0.11***
	(4.32)	(1.90)	(3.48)	(3.32)
Low Impact CEO	0.35	7.16	-0.01	0.08**
	(0.52)	(0.82)	(-0.13)	(2.40)
Controls	Yes	Yes	Yes	Yes
Observations	1,320	1,320	1,320	1,320
R-squared	0.33	0.40	0.31	0.33
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes

Appendix A
Data Filtering Process

	Number of Remaining Firms
US IPOs in SDC Global New issues Initial Public Offerings dataset for 1992–2010	6,656
Excluded financial institutions and utility firms, spin-offs from parent, depository shares, limited partnerships, unit offering, and IPOs with offer price per share less than 5 dollars.	3,908
Retained only those IPOs that are identified as "high-technology" by SDC.	2,286
Removed observations that do not have the required data in CRSP/COMPUSTAT for all control variables	1,569
Final sample for which the CEO information is available at the time of IPO	1,458

Appendix B
Variable Definitions and Data Sources

Variable	Description and Source
Panel A: CEO Characteristics	
Inventor CEO	A dummy variable that equals one in year *t* if the CEO has at least one patent in his or her name filed in the year of IPO or earlier, and zero otherwise. (Sources: Information about inventors come from Inventor Database of Lai, D'Amour, Yu, Sun, and Fleming (2013); we follow an elaborate process, described in detail in Section 4B, to match it with CEO identities obtained from a number of datasets including Execucomp, Capital IQ Professional Database, Web pages of companies, Bloomberg, DataStream, Google searches, and others).
Founder CEO	A dummy variable that equals one if the CEO was a founder of the company, and zero otherwise. (Source: Information assembled from various sources including Capital IQ Professional Database, Field–Ritter dataset, DataStream, Compustat Capital IQ People Intelligence Compensation Summary Database; Missing incorporation dates are collected from the web pages of companies, and other internet websites.)
Panel B: Firm/Deal Characteristics	
Underpricing	Stock return on the first day of trading in percentage terms, calculated as the closing price on the first day less the offer price, divided by the offer price.
Ln(Total Assets)	Natural logarithm of the book value of the firm's total assets. (Source: Compustat)
R&D/Total Assets	R&D expenditure divided by total assets. (Source: Compustat)
Ln (Age)	Natural logarithm of (one plus) the number of years since the firm was founded, measured at the time of the IPO.
V*C Backed*	An indicator variable set to one if the IPO is backed by one or more venture capital funds, else zero.
Positive EPS	An indicator variable set to one if earnings per share (eps) is positive at the time of the IPO, else zero.
Bubble Period	An indicator variable that equals one for the period September 1998 to August 2000, and zero otherwise (as in Lowry, Officer, Schwert, 2010).
ROA	Net operating profit divided by total assets. (Source: Compustat)
Panel C: Innovation Measures	
Firm Patents	The cumulative number of patents filed by a firm (that were subsequently granted) up until its IPO. (Source: 2010 version of NBER patent data compiled by KPSS)

Patents	The number of patents filed in a year by the firm (that were subsequently granted) averaged over the three-year post-IPO period. We correct for the well-known truncation problem in patent counts by using the truncation correction weights that are calculated from the application-grant lag distributions as described in Hall, Jaffe and Trajtenberg (2001). (Source: 2010 version of NBER patent data compiled by KPSS)
Pre-IPO Patents	The number of patents filed in a year by the firm (that were subsequently granted) averaged over the three years preceding the IPO. (Source: 2010 version of NBER patent data compiled by KPSS)
Citations	The total number of future citations, excluding self-citations, received by the firm's patents filed in a year, averaged over the three-year post-IPO period. The citation count for each patent is corrected for the well-known truncation bias by dividing it by the average number of citations received in the same two-digit technological field in the same application year. (Source: 2010 version of NBER patent data compiled by KPSS)
Pre-IPO Citations	The total number of future citations, excluding self-citations, received by the firm's patents filed in a year, averaged over the three-year preceding the IPO. (Source: 2010 version of NBER patent data compiled by KPSS)
Top 1% Patent	The number of patents filed by a firm in a year that fall in the top 1% of the distribution of future citations in the same technological field, averaged over the three-year post-IPO period. Self-citations are excluded. (Source: 2010 version of NBER patent data compiled by KPSS)
Pre-IPO Top 1% Patent	The top 1% of the distribution of future citations in the same technological field, averaged over the three years preceding the IPO. Self-citations are excluded. (Source: 2010 version of NBER patent data compiled by KPSS)
Top 5% Patent	The number of patents filed by a firm in a year that fall in the top 5% of the distribution of future citations in the same technological field, averaged over the three-year post-IPO period. Self-citations are excluded. (Source: 2010 version of NBER patent data compiled by KPSS)
Pre-IPO Top 5% Patent	The top 1% of the distribution of future citations in the same technological field, averaged over the three years preceding the IPO. (Source: 2010 version of NBER patent data compiled by KPSS)
Generality	Average of the yearly Generality measures computed for the three-year post-IPO period. Generality measure considers the forward citations received by the patents. It is computed as one minus the Herfindahl index of the citations received by the patents that a firm applied for in a given year across two-digit technological classes. A high value indicates that a firm's patents are cited by subsequent patents across a wide range of fields. (Source: 2010 version of NBER patent data compiled by KPSS)

Pre-IPO Generality	Average of the yearly Generality measures computed for the three-year preceding the IPO. (Source: 2010 version of NBER patent data compiled by KPSS)
Originality	Average of the yearly Originality measures computed for the three-year post-IPO period. Originality measure considers the backward citations made by the firm in its patents. It is computed as one minus the Herfindahl index of the citations made by the patents that a firm applied for in a given year across two-digit technological classes. A high value indicates that the preceding patents cited belong to a wider set of technological classes. (Source: 2010 version of NBER patent data compiled by KPSS)
Pre-IPO Originality	Average of the yearly Generality measures computed for the three-year preceding the IPO. (Source: 2010 version of NBER patent data compiled by KPSS)