Do Venture Capital-Driven Top Management Changes Enhance Corporate Innovation in Private Firms?

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Abstract

Using a hand-collected dataset on top management teams in venture capital-backed private firms, I analyze the effect of top management changes on subsequent corporate innovation in these firms. I find that top management changes are associated with significantly more and higher quality corporate innovation, as measured by patent counts and patent citations, respectively. I show that top management changes in these firms are likely to be venture-driven and that the effect of top management changes on corporate innovation is stronger for firms in which venture capitalists have greater power. An instrumental variable analysis using a plausibly exogenous shock to the supply of outside managers available for hire implies a positive causal effect of top management changes on corporate innovation. Further, I find that adding new managers has a significantly positive effect on innovation, while removing existing managers does not. Delving deeper into the educational background and employment history of each new manager added to the management team, I find that adding seasoned CEOs has a significantly positive effect on innovation, while adding senior managers with a prior technical background does not. I also analyze the possible mechanisms through which top management changes affect corporate innovation, and establish that one such mechanism is through new management teams hiring a greater number of inventors for a given investment size. Finally, I find that both top management changes and corporate innovation output have a positive impact on the probability of a successful exit (IPO/acquisition).

Keywords: Venture Capital; Top Management Changes; Corporate Innovation; Inventor Mobility

JEL Classification: G24; G30; O31; O32

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1 Introduction

The role of venture capital (VC) in creating value for the entrepreneurial firms has been widely debated in the literature. At least since the early work of Gorman and Sahlman (1989), a number of studies have suggested that venture capitalists take an active role in the portfolio companies that they finance beyond providing capital (see, e.g., Lerner (1995) and Hellmann and Puri (2002)). One channel through which VCs may add value to their portfolio companies is by improving their management team, either by adding new managers in areas where the firm is lacking in managerial expertise or by removing managers who underperform. Further, VC investments typically focus on high technology and high growth sectors of the economy, such as information technology, life sciences, and energy technology (Da Rin, Hellmann, and Puri (2013)), where innovation is a critical driver of their long-term growth and competitive advantage. This means that one measure by which one can judge the effectiveness of venture capitalists in recruiting new managers or removing underperforming managers is by studying the effect of such venture-driven top management changes on the innovativeness of their portfolio companies. However, to the best of my knowledge, there is little analysis of the relation between top management changes and corporate innovation in venture-backed private firms. In this paper, I use a unique hand-collected dataset to fill this gap in the literature by providing new evidence on how top management changes affect corporate innovation in venture-backed private firms and on the possible mechanisms through which this occurs.

I explore several interesting research questions regarding the effect of top management changes on corporate innovation. First, do top management changes lead to more and higher quality innovation? Second, is the probability of top management changes in venture-backed firms higher in firms where VCs have greater power (e.g., greater board membership)? Further, is the relation between top management changes and corporate innovation stronger in such firms? Third, as top management changes may include adding new managers as well as removing existing managers, how does each of these actions affect corporate innovation? Fourth, what type of top management background (in terms of educational and employment experience) is important in spurring innovation? In particular, are managers with general managerial skills (having worked as a CEO in another company), or those with a prior technical background (having engaged in the research and development process themselves), or both, important in spurring innovation?[1] Fifth, what are the underlying mechanisms through which top management changes affect corporate innovation in venture-backed private firms? Finally, how do top management changes and enhanced innovativeness affect the probability of a successful exit (either through an IPO or an acquisition) of venture-backed private firms?

The empirical analysis of the relation between top management changes and corporate innovation in venture-backed private firms is hampered by two major challenges. First, the data (especially management team and board of directors data) on venture-backed private firms is very limited. Second, potential endogeneity may confound any empirical analysis on the relation between top management changes and corporate innovation. On the one hand, one may argue that the relationship between top management changes and corporate innovation may be largely driven by omitted variables such as the underlying quality (innovativeness) of the firm, i.e., both top management changes and corporate innovation may be positively related to firm quality, in which case OLS regression estimates linking top management changes and corporate innovation will be biased upwards. On the other hand, venture capitalists may be more likely to intervene in firms (i.e., induce management changes) when they are performing poorly in order to help them improve their performance, in which case OLS regression estimates will be biased downwards.

I overcome the first challenge by constructing a unique hand-collected dataset of top management team and board information of venture-backed private firms, using which I can identify the top managers as well as board of directors for each firm across different financing rounds. I begin with all the venture-backed deals covered in VentureXpert over the period of 2002-2010 and hand-collect top management team and board information for these venture-backed private firms in each

[1] Anecdotal evidence suggests that venture-backed entrepreneurial firms may add seasoned CEOs as well as top managers with a prior technical background to help firms succeed. For example, SpaceClaim Corporation, a provider of 3D Modeling Software based in Concord, Massachusetts, announced the addition of Michael McGuinness (a seasoned CEO and President with rich software industry experience) to its top management team right before it received the third round of VC financing. SpaceClaim commented that McGuinness brought to SpaceClaim "broad executive experience across several industries" and strategic vision in high technology, management, and business development. See more details at http://www.spaceclaim.com/fr/company/news/pressreleases/07-03-20/SpaceClaim_Announces_Addition_of_Michael_McGuinness_as_Chief_Operating_Officer.aspx. An example of a venture-backed firm that added a top manager with a prior technical background is Acceleron Pharma, Inc., a biopharmaceutical company based in Cambridge, Massachusetts. Acceleron announced the appointment of Matthew L. Sherman, M.D. (who was responsible for clinical research and clinical operations in another pharmaceutical company prior to joining Acceleron and published a number of research papers) as Senior Vice President and Chief Medical Officer when it received VC financing in 2006. The company claimed that the addition of Sherman brought to Acceleron "broad scientific and clinical research knowledge along with his experience and proven record of building clinical development organizations." See more details at http://investor.acceleronpharma.com/releasedetail.cfm?ReleaseID=785744.

financing round from their "Form D" filings on the SEC EDGAR website. Many venture-backed firms use exemptions under Regulation D, which allow them to sell equity to accredited investors (such as venture capitalists) without having to register with the SEC and become a public company. When relying on Regulation D, firms are required to file a Form D, which is a brief notice that contains important information about the firm and the offering, including the names and addresses of the firm's executive officers (such as CEO, president, Chief Technology Officer) and directors, the amount of investment made by investors, and the date of sale.

I overcome the second challenge related to endogeneity using an instrumental variable analysis. I instrument for top management changes using a plausibly exogenous shock to the supply of outside managers that are able to move across firms and are available for hire by venture-backed private firms. Specifically, the instrument that I use is the number of acquisitions made by established firms in the same industry and in the same state as the venture-backed private firm multiplied by an index measuring the enforceability of non-compete clauses in that state. This instrument is motivated by the following facts. First, incoming managers to startups often come from established firms, and these firms are dominant players in the acquisition market. In other words, there is a strong correlation between the movement of executives across firms and the number of acquisitions made by established firms in the industry. Second, the enforceability of non-compete clauses, which are commonly used in employment contracts for top management to prohibit them from joining or founding a rival company, affects the mobility of managers across firms. In each stage of my IV regressions, I include industry-by-year and state-by-year fixed effects to absorb any industry-wide technology shock and any local economic shock that may affect innovation. Therefore, my instrument is unlikely to affect innovation through channels other than through its effect on the the ease of recruiting top management, thus satisfying the exclusion restriction.

My empirical results can be summarized as follows. First, I find that top management changes are associated with significantly more and higher quality corporate innovation subsequent to top management changes (as measured by patent counts and patent citations) in venture-backed private firms. For example, two-year patent counts and two-year patent citations increase by 14% and 11.7%, respectively, following top management changes. Second, I show that the probability of management changes is increasing with the power of venture capitalists in the firm (as measured by the number of outside board members), suggesting that management changes in my venture-backed sample are primarily driven by venture capitalists.[2] Further, I find that the effect of management changes on corporate innovation is stronger for firms where venture capitalists have greater power, consistent with the conjecture that venture capitalists add value to their portfolio companies through inducing management changes. My instrumental variable analysis (making use of a plausibly exogenous shock to the supply of outside managers as described above) shows that the positive relationship that I documented earlier between management changes and corporate innovation is causal. Third, I find that adding new managers has a positive and significant effect on the quantity and quality of future innovation, while removing existing managers does not. Fourth, I find that adding seasoned CEOs has a positive and significant effect on innovation, while adding senior managers with a prior technical background does not.

I then investigate the possible underlying mechanisms through which top management changes may foster greater innovation activities. I hypothesize that the new management teams may select and allocate resources to higher quality innovation projects, manage innovative assets more efficiently, and provide a better environment for inventors (i.e., scientists and engineers) to succeed in the firm (for example, by creating a more failure-tolerant environment for inventors, in the sense of Manso (2011)). Thus, one way that top management changes may enhance corporate innovation is by the new management team being able to hire more inventors to work for the firm (for a given amount of resources available). My result is consistent with this conjecture: I find that top management changes are associated with a significantly greater net inflow (inflow minus outflow) of inventors in the two or three years following top management changes. Further, the positive relation between top management changes and the net inflow of inventors is stronger for firms where VCs have greater power.

Finally, I explore the relation between top management changes, corporate innovation, and successful exit outcomes (as measured by an IPO or an acquisition by another company) in venture-backed private firms. I find that both management changes and innovation output are significantly and positively related to the probability of successful exit outcomes. I also show that the effect

[2] I follow the existing literature (see, e.g., Ewens and Marx (2014)) in making use of the number of outside board members as a measure for the power of VCs in the firm. Typically, outside board members in venture-backed private firms are composed of investors (e.g., VCs) and independent observers (see Kaplan and Strömberg (2003) and Ewens and Marx (2014) for details). The existing literature has documented that other outside board members are likely to vote along with VCs (especially when the venture-backed firm performs poorly), thus justifying the use of the number of outside board members as a proxy for the power of VCs in the firm.

of top management changes on the successful exit is at least partly mediated through enhanced innovation.

I conduct a number of robustness tests and find that the positive relation between top management changes and corporate innovation that I documented earlier is robust to these tests. First, I find that the positive relation between management changes and corporate innovation is robust to controlling for industry-by-state-by-year fixed effects. As my instrumental variable analysis makes use of variation at the industry-by-state-by-year level, this helps to alleviate the concern that that industry-by-state-by-year level omitted variables may drive both management changes and corporate innovation. Second, to alleviate the concern that corporate innovation may be driven by a general trend of technological development, I conduct a placebo test using innovation output generated prior to management changes as the dependent variable. I find that the relation between management changes and prior innovation is insignificant, suggesting that the positive relation between management changes and future innovation is unlikely to be due to a general trend of technological development. Third, I show that the positive relation that I documented earlier between top management changes and corporate innovation is robust to controlling for lead VC firm fixed effects. The results of this robustness test confirm that the positive relation between top management changes and innovation is not driven by any unobservable and time-invariant VC firm characteristics that may affect innovation (such as VC firms' project selection ability and preferences).

My paper is related to a number of studies and contributes to several strands in the literature. First, it improves our understanding on how venture capitalists add value to the entrepreneurial firms that they invest in through active intervention in recruiting top management. Several existing studies show that VCs play a role in recruiting managers (especially CEOs) and replacing founders. For example, Hellmann and Puri (2002) use a sample of 170 Silicon Valley startups and show that venture capitalists professionalize nascent firms by instituting human resource policies and bringing in professional CEOs to replace founders. They, however, do not study the effect of such management changes on any subsequent outcomes (including innovation). Wasserman (2003) shows that raising financing from outside investors (mainly VCs) leads to higher chances of founder-CEO being replaced by an outside CEO, using a sample of 202 Internet startups. Amornsiripanitch, Gompers, and Xuan (2016) show that successful VCs who have a good track record of past investment and a large network are likely to hire outside managers and outside board members. Ewens and Marx (2014) find that venture capitalists are more likely to replace senior managers in struggling startups to "correct the ship" and establish a causal relationship between management replacements and better exit outcomes. In summary, none of the above papers study the relationship between top management changes and product market innovation in venture-backed private firms, which is the focus of this paper.

Second, my paper adds to the literature on how venture-backing improves innovation or efficiency, by establishing the link between a specific action by venture capitalists (i.e., top management changes) and corporate innovation. Several papers study how VC-backing affects innovation in venture-backed firms, relative to non-venture-backed firms, while other studies attempt to identify the relationship between VC characteristics (such as experience, industry expertise, syndication, staged capital infusion, and failure tolerance) and innovation in venture-backed firms. Recent studies include Chemmanur, Loutskina, and Tian (2014), Tian (2011), and Tian and Wang (2014), Bernstein, Giroud, and Townsend (2015), etc. Another literature is the one studying whether VC-backing improves efficiency in private firms and the mechanisms through which they do so (see, e.g., Chemmanur, Krishnan, and Nandy (2011)).[3]

Third, this study sheds significant light on the top management changes/turnover literature. Existing studies have shown that management changes are important corporate events. In particular, there is empirical evidence documenting improvements in accounting and stock performances following CEO turnover mainly for large public companies (Huson, Malatesta, and Parrino (2004); Denis and Denis (1995); Cornelli, Kominek, and Lungquivst (2013)). Bereskin and Hsu (2013) study the effect of CEO turnover on corporate innovation in large public companies. However, with a few exceptions (Gao, Harford, and Li (2015) and Cornelli and Karakaş (2015)), the literature above focuses on the publicly traded firms and provides few insights into management changes in private firms due to data limitations.[4] My paper adds to the literature by examining for the first time, the effect of top management changes on corporate innovation in venture-backed private firms.

[3]See Da Rin, Hellmann, and Puri (2013), who provide an excellent survey of the broader venture capital literature.

[4]Gao, Harford, and Li (2015) find that public firms have higher CEO turnover rates and exhibit greater CEO turnover-performance sensitivities than large private firms, using a sample of US public firms and large private firms. Cornelli and Karakaş (2015) find that CEO turnover decreases and is less contingent on performance when a firm is taken private, using a sample of LBO firms in the UK.

Finally, this study proposes a channel through which top management changes may affect corporate innovation, suggesting that the new management team may enhance innovation by attracting a greater number of inventors. Thus my study contributes to a small but growing literature on labor mobility and innovator flows (e.g., Marx, Strumsky, and Fleming (2009) and Chemmanur, Kong, Krishnan, and Yu (2016)).

The rest of the paper is organized as follows. Section 2 discusses the underlying theory and develops testable hypotheses. Section 3 outlines the data and the sample selection procedure. Section 4 provides a discussion of my main empirical tests and results. Section 5 presents a discussion of my robustness test results. Section 6 concludes.

2 Theory and Hypothesis Development

In this section, I briefly review the underlying theory and develop testable hypotheses for my empirical tests. Existing literature offers several explanations for why management changes can create firm value. One view is that top management changes are part of an error correction process. The new management teams may reverse the bad decisions of past management teams and reallocate resources to more promising projects (e.g., Boot (1992) and Weisbach (1995)).[5] Another view is that new managers may bring additional resources to the firm (such as additional human capital) and may establish complementarities between these new resources and existing human capital, which can create value for the firm (e.g., Oyer and Schaefer (2011), Pan (2015), and Huang (2014)).[6] Based on both theories, if the new management team can correct bad decisions and reallocate resources to more innovative projects, or if they can bring additional human capital enabling them to select more innovative projects and manage these projects more ably, I would expect management changes to be associated with significantly more and higher quality corporate innovation output. This is the first hypothesis that I test here (**H1**).

[5]Boot (1992) theorizes that unskilled managers are reluctant to divest because a divesture is an admission of a mistake. Therefore, on average, there is too little divesture relative to the shareholders' optimum. Consistent with Boot's implications, Weisbach (1995) finds that the probability of divesting poorly performing projects increases after CEO turnover.

[6]Oyer and Schaefer (2011) suggest that management attributes (such as talents, skills, or experience) may complement certain production technologies and improve productivity of the firm. Pan (2015) uses a model of executive-firm matching and shows that complementarity between the firm and management attributes may lead to increased productivity of the firm. Huang (2014) investigates how the complementarity between managers' industry experience and the firm affects firm value. His empirical findings show that CEOs in conglomerates are more likely to refocus on divisions in which they have specialized and divest those in which they have less experience.

Existing studies have suggested that VCs provide value-added services to the companies that they finance. They are known to take an active role in recruiting senior management, either by bringing in new (and professional) managers to expand the management team or by removing existing managers (see, e.g., Gorman and Sahlman (1989), Lerner (1995) and Hellmann and Puri (2002)). If management changes in venture-backed private firms are likely to be driven by venture capitalists, i.e., venture capitalist proactively add or remove managers in the firms they back to help them succeed rather than replacing managers who resign from the firm voluntarily (possibly due to getting attractive outside opportunities or losing interest in the current firm), then I would expect the probability of top management changes to increase with the power of venture capitalists in the firm. Further, if management changes are truly a source of value-addition, I would expect the effect of management changes on innovation to be stronger for firms where VCs have greater power. This is the second hypothesis that I test here (**H2**).

As top management changes may include adding new managers as well as removing existing mangers (or both), I then explore how each of these actions may affect corporate innovation. As suggested in existing studies (e.g., Boot (1992)), removing existing managers may result in correcting past errors in terms of investment and other decisions, such as abandoning poorly performing projects. If so, I would expect removing existing managers to be positively related with the quantity and quality of innovation. Further, if top management changes are indeed a source of value-addition by VCs, I would expect the relation between removing existing managers and innovation to be stronger in firms where VCs have more power (**H3**). Existing studies (e.g., Oyer and Schaefer (2011)) also suggest that adding new managers may bring in new blood to the firm's existing human capital, in addition to correcting past errors. If so, I would expect adding new managers to be positively related to the quantity and quality of corporate innovation. Further, I expect such a relation to be stronger in firms where VCs have more power (**H4**). These two relations are not mutually exclusive and both may exist from *a priori* theoretical considerations.

Further, I delve deeper into the background of the new management teams and study how different background of the managers may play a role in affecting innovation. One possibility is that the new managers with general managerial skills (for example, who have worked as a CEO or president before) are better at allocating resources, managing assets, and attracting human capital and thus enhance innovation. If so, I would expect adding seasoned CEOs (or presidents) to the firm's top management team (not necessarily as a CEO or president) to have a positive effect on the quantity and quality of innovation (**H5**). Another possibility is that the new managers with a prior technical background (for example, who either hold a research degree in a field related to the firm's business or have engaged in the research and development process in another company) are better at selecting innovative projects to invest in and participating in the development process due to their technical skills and research experience. If so, I would expect adding such managers to have a positive effect on the quantity and quality of innovation (**H6**). Again, these two effects are not mutually exclusive to each other and both may exist.

I now turn to an analysis of the possible underlying mechanisms through which management changes may enhance corporate innovation in venture-backed firms. One possible mechanism is through the inventor mobility channel. New management teams may select and allocate resources to more innovative projects, manage innovative assets better, and provide a better environment for inventors to succeed (for example, by creating a more failure-tolerant environment for inventors, in the sense of Manso (2011)). This, in turn, may enable the firm to attract more inventors. Therefore, I would expect management changes to be associated with a greater net inflow of inventors. Further, if VCs have greater power in the firm, they may be more effective in using top management changes to create value for the firm through the inventor mobility channel. I would therefore expect the effect of management changes on the net inflow of inventors to be stronger in firms where VCs have greater power (**H7**).

Finally, I investigate the effect of venture capital-driven top management changes as well as enhanced innovation output on the probability of successful exit (either through an IPO or an acquisition) for venture-backed firms. First, if one of the ways in which venture capitalists add value to a firm that they invest in is by inducing top management changes when appropriate (either by adding or removing managers), then I would expect such top management changes to be positively associated with the probability of successful exit (**H8**). Second, since successful innovations are likely to be associated with positive net present value investment opportunities, I would expect firms with greater innovative success to be associated with a higher probability of a successful exit (**H9**).

3 Data and Sample Selection

3.1 Sample Selection

My sample is derived from multiple data sources. I begin with all the VC-backed deals (VC investments) with at least two financing rounds over the period of 2002-2010 covered in the VentureXpert database. I require that the first round information and the amount of investment made by VCs for all the rounds must be available. This leaves us with 19201 firm-financing round observations and 1777 distinct venture-backed firms. Then I randomly select 50% of these firms for hand collection of the information of their management team and board of directors.[7]

I hand-collect the management team and board member information for each selected firm from the "Form D" filings on the SEC website. Under the Securities Act of 1933, any offer to sell securities must either be registered with the SEC (which will make the company selling securities a public company) or meet an exemption. Regulation D (or Reg D) contains three rules providing exemptions from the registration requirements, i.e., the Reg D private placement is an equity-financing alternative to a public offering. Many venture-backed private firms use exemptions under Reg D to sell equity to the venture capitalists. Firms relying on a Reg D exemption are required to file a "Form D," which is a brief notice that includes the names and addresses of the company's top managers (such as CEO, president, Chief Technology Officer, and VP Finance), board of directors, size of the offering, and date of the sale.[8,9] Therefore, for each firm-financing round observation in the selected deals from the VentureXpert database as described above, I search the firms for their Form D filings on the SEC EDGAR website based on the name of the company, the filing date, and the amount of investment by VCs and hand-collect the names of each member on the management team as well as board of directors for these venture-backed firms.

I hand-collect firm-year patent and citation information from the USPTO website based on the names and addresses of the venture-backed entrepreneurial firms in my sample. I collect the inventor information associated with each patent from the U.S. Patent Inventor Database (1975-

[7] In the current stage, I randomly select 50% of the deals for hand collection. I compared the distribution of the selected deals with the whole sample and confirm that the selected deals are representative of the whole sample.

[8] See a detailed description about Form D at http://www.sec.gov/answers/formd.htm.

[9] Although firms are not required to disclose each manager's specific title in Form D, they have to disclose the names and titles of the managers who signed the document. From the names and titles of these signers, I am able to identify the titles of the managers that may be included in Form D.

2010) (see Li, Lai, D'Amour, Doolin, Sun, Torvik, Yu, and Fleming (2014)). Information on the successful exit outcomes of these venture-backed entrepreneurial firms (as measured by an IPO or an acquisition by another company) comes from the SDC Global New Issues database and the SDC Mergers & Acquisitions database, respectively.

The final merged sample results in 434 firms and 977 firm-financing round observations.[10] Most of my sample firms stay private and active under VC investment over 2002-2010, while about 5% of the these firms exited through an IPO and 21% of them exited through an acquisition within ten years after receiving the first round of VC financing.[11] A typical venture-backed firm in my sample receives $5.5 million investment from VCs per round. The median number of investors in a syndicate is 2. Firms headquartered in Massachusetts and California account for 15% and 41% of the sample firms, respectively. These statistics of my sample are comparable to those documented in the existing literature (e.g., Tian (2011) and Ewens and Marx (2014)).

3.2 Measures of Top Management Changes

The main explanatory variable, *Mgmt Change*, is an indicator variable equal to one for a firm-financing round if the composition of the firm's top management team in the current round is different from that in the previous round and zero otherwise. Specifically, the indicator is turned on if either new managers were added to the top management team or existing managers from the previous financing round were removed from the top management team in the current round. As management changes may include adding new managers to expand team, removing existing managers from the team, or both, I therefore create three separate indicators for each of the above three cases. *Add Only* is a dummy variable equal to one if new managers were added to the management team for a firm-round but no existing managers were removed, and zero otherwise; *Remove Only* is a dummy variable equal to one if existing managers were removed from the management team for a firm-round but no new managers were added, and zero otherwise; *Both* is a dummy variable equal to one if new managers were added to and existing managers were removed from a firm's management team as well for a firm-round observation, and zero otherwise. I also use two sets of continuous variables, namely, the natural log of one plus the number (or fraction) of new managers

[10] If a firm receives more than one round of VC financing within one year, I aggregate these observations into one firm-round year observation.

[11] In total, 25% of the sample firms were eventually acquired by another company.

added and the natural log of one plus the number (or fraction) of existing managers, as alternative measures for adding new managers and removing existing managers.

3.3 Measures of Corporate Innovation

Following the existing literature (e.g., Hall, Jaffe, and Trajtenberg (2001), Chemmanur, Loutskina, and Tian (2014), and Seru (2014)), I use patent-based metrics to capture firm innovativeness. I hand-collect the patent information associated with each firm in my venture-backed sample based on the name and address of the firm from the USPTO website.[12]

Patent data is subject to two types of truncation bias. First, patents are recorded on the USPTO website only after they are granted and the lag between patent applications and patent grants is significant (about two years on average). Therefore, we observe a smaller number of patent applications that are eventually granted towards the end of my sample period. Many patent applications filed during these years were still under review and had not yet been granted. I mitigate this bias by restricting my analyses to patents that are filed up to 2010. The second type of truncation problem is stemming from citation counts (i.e., the total number of citations received till now). Patents tend to receive citations over a long period of time, so the citation counts of more recent patents are significantly downward biased. Following Seru (2014), this bias is accounted for by scaling citations of a given patent by the mean number of citations received by all patents in that year in the same 3-digit technology class as the patent. Note that the above methodology gives us class-adjusted measures of patents and citations, which adjust for trends in innovative activity in particular industries.

Specifically, I use the following variables to measure the quantity and quality of innovation output, respectively: $Patents^{(N)} = Ln(1+\sum_{\tau=1}^{N} Patents_{i,t+\tau})$, and $Cites^{(N)} = Ln(1+\sum_{\tau=1}^{N} Cites_{i,t+\tau})$, where $N = 2$ or 3.[13] These proxies represent the natural log of one plus patent counts and citation counts over the following two or three years, and the log-linearization is used to mitigate skewness following Lerner (1995). $Patents_{i,t}$ is firm i's patent counts in year t, defined as the total number of patent applications filed by firm i in year t that were finally granted. $Cites_{i,t}$ is firm i's patent

[12] I collected the patent data from the USPTO website in March, 2015. Therefore, my patent sample includes patents that were granted up to March, 2015.

[13] In untabulated analyses, I conduct regressions using these dependent variables where N=4 or 5. The results are qualitatively similar but weaker due to decreased sample size.

citations in year t, defined as the number of adjusted number of citations received by all patents filed by firm i in year t. Table 1 reports the summary statistics for my innovation measures. For example, $Patents^{(2)}$ has a mean value of 0.50 and a median value of zero; $Cites^{(2)}$ has a mean value of 0.40 and a median value of zero.

3.4 Measures of Inventor Mobility

To identify the inventor mobility, I collect inventor information of each patent from the U.S Patent Inventor Database (1975-2010) (see Li, Lai, D'Amour, Doolin, Sun, Torvik, Yu, and Fleming (2014)). The U.S. Patent Inventor Database includes inventor names, inventor addresses, assignee names, application date, and grant date for each patent. More importantly, it identifies unique inventors over time so that we could possibly track the moves of each inventor. Following Marx, Strumsky, and Fleming (2009), I identify mobile inventors as changing employers if he has ever filed two successive patent applications that are assigned to different firms (or organizations). As I need at least two patents to detect a move, inventors that have filed a single patent throughout their career are necessarily excluded from my analysis.

I assume the inventor's move to occur in the year when he filed his first patent in a given firm. For a given firm, an inventor's move-in year is the year when he filed his first patent in this firm; the inventor's move-out year is the year when he filed his first patent in the subsequent firm. For the inventor's very last employer, I assume that the inventor stayed with that firm and did not move out.[14] For example, in the inventor database, an inventor named Christopher L. Holderness has filed two patent applications till 2010. He filed patent application with Corning Inc. in 1999 and then with Dell Inc. in 2003. In accordance with my assumption, for Corning, Mr. Holderness's move-in year is 1999 and move-out year is 2003; and for Dell, Mr. Holderness's move-in year is 2003, and he has stayed with Dell since 2003. Once I identify each mobile inventor's move-in and move-out year, I aggregate the number of mobile inventors that move in and move out at the firm-year level to obtain the total inflow and outflow of mobile inventors for a given firm in a year. I define the difference between the natural logarithm of one plus the inflow and the natural logarithm of one plus the outflow as the net inflow of mobile inventors. For firms without any mobile inventors,

[14] As a robustness check, I redefine the dates that the inventor moved out of his last employer as one or two years after he filed his last patent in that firm. My results remain qualitatively similar with this alternative definition.

I assign zero values to the inflow, outflow, and net inflow of mobile inventors. I use the following variables to measure the cumulative inflow, outflow, and net inflow of mobile inventors in the next N years following management changes, respectively: $Inflow^{(N)} = Ln(1 + \sum_{\tau=1}^{N} Inflow_{i,t+\tau})$, $Outflow^{(N)} = Ln(1+\sum_{\tau=1}^{N} Outflow_{i,t+\tau})$, and $Net\ Inflow^{(N)} = Inflow^{(N)} - Outflow^{(N)}$, where N=2 or 3.

3.5 Other Variables

I control for the following characteristics and fixed effects that may affect firms' innovation output following the literature (see, for example, Chemmanur, Loutskina, and Tian (2014), Tian (2011), Chemmanur, Krishnan, Kong, and Yu (2016), and Tian and Wang (2014)). In the baseline regressions, my control variables include the following: *Ln(VC Investment)*, which is defined as the natural log of the VC investment amount for a firm-financing round; *Ln(Syndicate Size)*, which is defined as the natural log of one plus the number of investing VCs; and *Ln(Mgmt Team Size)*, which is defined as the natural log of one plus the number of managers in a firm's top management team. Table 1 provides summary statistics for the control variables described above. For example, *Ln(VC Investment)* has a mean value of 8.48 and a median value of 8.61. A typical firm in my sample has a top management team composed of two senior managers and receives VC funding from three syndicating venture capitalists. In all regressions, I also include industry fixed effects (defined at the 2-digit SIC code level), year of financing round fixed effects, and development stage fixed effects, unless otherwise specified.

4 Empirical Results

4.1 The Effect of Top Management Changes on Corporate Innovation

I expect top management changes to be associated with significantly more and higher quality corporate innovation, as measured by patent counts and the total number of citations, respectively. In this section, I empirically test this hypothesis (**H1**) by estimating the following model:

$$Innovation^{(N)} = \alpha + \beta Mgmt\ Change_{i,t} + \gamma Z_{i,t} + Industry + Year + Stage + \epsilon_{i,t}, \quad (1)$$

where i indexes firm and t indexes time and N equals two or three. $Innovation^{(N)}$ are the two-year or three-year patent counts and patent citations described earlier. Since the innovation process takes time, I examine the cumulative effect of a firm's management changes on its innovation within two or three years following management changes.[15] The main explanatory variable, *Mgmt Change*, is measured for firm i over year t, which is the year of the current financing round. Z is a vector of control variables that may affect a firm's innovation output, which includes *Ln(VC Investment)*, *Ln(Syndicate Size)*, and *Ln(Mgmt Team Size)*, as described in Section 3.5. Industry fixed effects (defined at 2-digit SIC code level), year fixed effects, and development stage fixed effects are also included. In all regressions throughout the paper, standard error are clustered at the industry level unless otherwise specified.

Table 2 reports the OLS estimation results for regression (1). Columns (1) and (2) report results for the regressions using the cumulative two-year patent counts and patent citations as dependent variables, respectively; while Columns (3) and (4) report results for the regressions using the cumulative three-year patent counts and patent citations, respectively. In almost all the specifications, the coefficients on *Mgmt Change* are positive and significant at least at the 5% level. The coefficient in Column (4) is still positive but becomes insignificant due to increased standard errors. The economic magnitude of the effect of management changes on innovation is significant as well: for example, Column (1) suggests that two-year patent counts increase by 14% following management changes, and Column (2) suggests that two-year patent citations increase by 11.4% following management changes. Collectively, these results suggest that management changes are associated with significantly more and higher quality future innovation, which is consistent with **H1**.

4.2 The Effect of Top Management Changes on Corporate Innovation for Firms with Different VC Power

The results in the above section suggest a positive link between management changes and corporate innovation. In this section, I first show that top management changes in my venture-backed sample are likely to be driven by venture capitalists. Then I explore whether the positive relation between

[15] As mentioned in Section 3.3, using dependent variables defined over longer horizons (i.e., within the next four or five years) gives qualitatively similar but weaker results due to decreased sample size.

venture-driven management changes and corporate innovation is stronger for firms where VCs have greater power.

As argued earlier, if venture capitalists proactively add or remove managers in venture-backed firms to help them succeed rather than replacing managers who resign from the firm voluntarily due to having attractive outside opportunities or losing interest in the firm, then I would expect that the probability of management changes increases with the power of VCs. I use the number of outside board members (i.e., board members that are not on the management team) to assess the power of VCs in venture-backed private firms. The board of a firm is known to be responsible for hiring, monitoring, and firing top management team. The board of directors in venture-backed entrepreneurial firms are usually composed of insiders (executive officers or founders), investors (e.g., VCs), and independent directors (who are mutually agreed upon both by investors and insiders, see Kaplan and Strömberg (2003) and Ewens and Marx (2014) for more details). Existing studies document that other outside board members are likely to vote along with VCs (especially when the firm performs poorly), thus justifying the use of outside board members as a proxy for the power of VC in the firm.[16]

To test whether management changes are likely to be driven by VCs, I estimate the following probit model using the *Mgmt Change* as the dependent variable:

$$\mathit{Prob(Mgmt\ Change)}_{i,t} = \alpha + \theta \, \mathit{VC\ Power}_{i,t} + \gamma Z_{i,t} + Industry + Year + Stage + \epsilon_{i,t}, \qquad (2)$$

where *VC Power* is measured by the natural log of one plus the number of outside board members.[17] I use the fraction of outside board members as an alternative measure. As the existing literature also documents that firm age may be an important determinant of the probability of management changes, I include *Ln(Firm Age)* as a control variable in addition to the set of controls used earlier.

Table 3 reports the results for the above probit model. Columns (1) uses natural log of one plus the outside board members as a proxy for the power of VCs in the venture-backed firm. The coefficient on *Ln(Outside Board Members)* is positive and significant at the 1% level, with the

[16]Existing studies show that outside board members are likely to play a role in changing management in venture-backed private firms (see, e.g., Kaplan and Strömberg (2003) and Ewens and Marx (2014)). Studies on the boards of public firms such as Weisbach (1988) and Knyazeva, Knyazeva, and Masulis (2013) show that the outside board size or board independence are connected with shareholder power and have a direct effect on CEO turnover.

[17]I add one to the the number of outside board members before taking logs to avoid losing observations.

predicted sign. The economic magnitude of the effect of VC power on changes is very significant. For example, the estimate in Column (1) implies that a one standard deviation increase in the log of the number of outside board members (0.49) is associated with a 9.1% increase in the probability of a management change.[18] Column (2) uses the fraction of outside board members as the main explanatory variable. As expected, the coefficient on *Fraction of Outside Board Members* is significantly positive. A one inter-quartile increase in the fraction of outside board members (0.3) is associated with 12.7% increase in the probability of a management change. Overall, the results in Table 3 provide strong evidence that management changes in my sample of venture-backed private firms are likely to be driven by venture capitalists.

Next, I use an interaction test to study whether the effect of management changes on corporate innovation is stronger for firms where VCs have greater power. I therefore interact *Mgmt Change* with an indicator for greater VC power (*High Power*) and test the following model:

$$\begin{aligned} Innovation^{(N)} &= \alpha + \beta Mgmt\ Change_{i,t} + \delta High\ Power_{i,t} + \theta Mgmt\ Change_{i,t} \times High\ Power_{i,t} \\ &+ \gamma Z_{i,t} + Industry + Year + Stage + \epsilon_{i,t}, \end{aligned} \tag{3}$$

where *High Power* is defined as a dummy variable equal to one if the number of outside board members is above the sample median and zero otherwise. Table 4 reports the results for these interaction tests. Consistent with my earlier conjectures, I find that the coefficient on the interaction between *Mgmt Change* and *High Power* is positive and significant at least at the 5% level for all the specifications. Once the interaction terms are included in the regressions, the effect of *Mgmt Change* becomes insignificant. These findings suggest that venture-driven management changes are more effective in enhancing innovation in firms where VCs have greater power, consistent with the notion that VCs add value to their portfolio companies through actively improving firm management. In sum, the results in this section lend support for **H2**.

[18]The predicted probability of a management change at the mean of control variables is 20.9%. Fixing means while increasing the outside board size by one standard deviation (0.49) results in a predicted probability of 30.1%.

4.3 The Effect of Top Management Changes on Corporate Innovation: Instrumental Variable Analysis

In my baseline (OLS regression) analysis, I find a positive association between top management changes and enhanced innovation activities subsequently in venture-backed private firms. However, potential endogeneity can confound empirical findings from the baseline analysis linking management changes and corporate innovation. On the one hand, one may argue that the positive relationship between management changes and corporate innovation may be driven by omitted variables such as firm quality or innovativeness, as venture capitalist may select more innovative firms to invest in. In this case, the OLS estimates will be biased upwards. On the other hand, venture capitalists may be more likely to intervene the firms when they are off the track to help them "correct the ship." In this case, the OLS estimates will be biased downwards. In order to address the above potential endogeneity concerns, I conduct an instrumental variable (IV) analysis using a plausibly exogenous shock to the supply of outside managers available for hire (who might serve as suitable replacements). Specifically, my instrument is constructed as the number of acquisitions made by public companies in the same industry and in the same state as the venture-backed private firm multiplied by an index measuring the enforceability of the non-compete clauses in that state.

The instrument in my IV analysis is motivated by the following facts. First, incoming managers to startups often come from established firms, and these firms are dominant players in the acquisition market. In other words, there is a strong correlation between the movement of managers across firms and the number of acquisitions in the industry that the firm belongs to. Inspired by Ewens and Marx (2014), I count the number of acquisitions made by established firms in the same industry and in the same state as the venture-backed entrepreneurial firms two years prior as a proxy for the local supply of outside managers for the venture-backed firms.[19] The two-year lag stems from the popular retention contracts employed by the acquirers for target firms. These contracts often compensate the managers of target firms for lost compensation for two to four years and provide strong incentives for these managers to stay with the target firms for another few years. The expiration of these contracts generates a source of variation to the potential supply of managers. Second, the enforceability of non-compete clauses, which are commonly used in employ-

[19]Ewens and Marx (2014) find a strong reduced-form correlation between executive replacement and the number of acquisitions in the same industry two years prior.

ment contracts for top management and prohibit them from joining or founding a rival company within one to two years of leaving, affects the mobility of managers across the firms.[20] Bishara, Martin, and Thomas (2015) analyze an extensive sample of CEO employment contracts and show that 80% of these contracts contain non-compete clauses, often with a broad geographic scope. A growing body of work (e.g., Garmaise (2009) and Marx, Strumsky, and Fleming (2009)) shows that higher enforceability of these non-compete clauses reduces employees' mobility (including that of managers). The enforceability of such non-compete clauses exhibits both cross-state and time series variation, which leads to variation in the mobility of managers that is unlikely to be directly related to innovation. Based on the above facts, I construct an instrumental variable for *Mgmt Change*, making use of the the strong correlation between industry acquisitions and the movement of top managers as well as the exogenous variation in the mobility of managers.

Specifically, the instrumental variable for *Mgmt Change* in a firm in industry j headquartered in state s in year t, is computed as follows:

$$Instrument_{j,t} = Acquisitions_{j,s,t-2} \times Enforceability\ Index_{s,t}, \tag{4}$$

where j, s, and t index industry, state, and year, respectively. $Acquisitions_{j,s,t-2}$ is the number of acquisitions made by established (public) companies in industry j in state s in year $t-2$. The information on mergers and acquisitions required to construct this variable is collected from the SDC Mergers & Acquisitions Database. Again, the two-year lag allows for the expiration of retention contracts that work as "golden handcuffs" for managers and thus $Acquisitions_{j,s,t-2}$ proxies for the potential supply of managers from state s in industry j in year t.

$Enforceability\ Index_{s,t}$ is the index measuring the enforceability of non-compete agreements across different US states based on Garmaise (2009). Garmaise (2009) develops an index to measure the enforceability of non-compete clauses by considering 12 questions analyzed by Malsberger (2004), which is the central resource describing noncompetition law in 50 US states and the DC, and assigning 1 point to each jurisdiction for each question if the jurisdiction's enforcement of that dimension of noncompetition law exceeds a certain threshold. Possible totals therefore range from

[20]Since these non-compete clauses become operational only when top managers leave their prior firms, the enforceability of these non-compete clauses can be thought as a measure of the friction facing top managers when they attempt to join the venture-backed private firm.

0 to 12.[21] The *Enforceability Index* used here is constructed as the difference between 12 and the value of Garmaise's (2009) index scaled by 12 and thus it potentially ranges from 0 to 1. Higher (lower) values of *Enforceability Index* indicates weaker (greater) enforceability of the non-compete clauses and thus greater (weaker) mobility of managers. The instrument therefore proxies for the supply of managers that are able to move across firms and available for hire by a venture-backed private firm in state s in industry j in year t. I expect my instrument to be positively and significantly related to the probability of top management changes (and empirically show this in my first-stage regression as in below).

To instrument for top managements change of firm i in industry j in year t, I therefore run the first-stage probit regression of my IV analysis as follows:[22,23]

$$\begin{aligned} Prob(Mgmt\ Change)_{i,j,t} &= \alpha + \beta Instrument_{j,t} + \gamma Z_{i,t} + Industry \times\ Year + State \times\ Year \\ &+ Stage + \epsilon_{i,t}. \end{aligned} \tag{5}$$

In each stage of my IV regressions, I include industry-by-year fixed effects and state-by-year fixed effects. These fixed effects help to absorb any industry-wide technology shock (e.g. innovation wave) and any local economic shock that may affect innovation. Therefore, the instrument is unlikely to affect innovation through channels other than through affecting the supply of managers and inducing top management changes, thus satisfying the exclusion restriction.

Table 5 report the first and second-stage results of my IV analysis. Column (1) reports the first-stage probit result. I find that the coefficient on my instrument is positive and significant at the 1% level, even after controlling for industry-wide shock and local economic shock. Pseudo R-squared is as large as 36.7%. The first stage F-statistic (Cragg-Donald Wald F statistic) for the weak instruments tests is 72.29 and is above the critical value as suggested in Stock and Yogo

[21] Higher values of Garmaise's (2009) index indicate higher enforceability of the non-compete agreements in this state and thus less mobility of the managers from this state. For example, Garmaise's index (2009) is equal to 0 for California and is equal to 9 for Florida after 1997.

[22] Since the endogenous variable *Mgmt Change* is binary, I use a probit model in the first stage, following Wooldrige (2010). I then compute the predicted probability ($\widehat{Mgmt\ Change}$) from the probit estimation in the first stage and use $\widehat{Mgmt\ Change}$ as the instrumental variable for *Mgmt Change* to estimate the effect of top management changes on corporate innovation. I obtain qualitatively similar results using linear models in each stage.

[23] As documented in Section 4.2, the power of VCs and firm age may be significant determinants of the probability of top management changes for a venture-backed private firms. I therefore include *Ln(Outside Board Members)* and *Ln(Firm Age)* as additional control variables in addition to those used in the baseline analysis, as described in Section 3.5.

(2005). These results indicate that the relevance condition is likely to be satisfied.

Columns (2)-(5) in Panels A of Table 5 report the second-stage results of my IV analysis. I find that management changes continue to have a significantly positive effect on the quantity and quality of subsequent innovation, even after accounting for the potential endogeneity concerns described earlier. Further, the coefficient estimates on *Mgmt Change* in my IV regression results become larger compared with the OLS regression estimates, suggesting that the OLS regression estimates are downward biased. This is like due to the fact that venture capitalists are more likely to intervene in firms that do not perform well and therefore management changes are more likely to occur in such firms.

In Panel B of Table 5, I report the IV(2SLS) results for the regressions that use the interaction term between management changes and a dummy variable for greater investor power as the main explanatory variable.[24] I find that the interaction terms load significantly and positively in all the specifications. This is consistent with my earlier findings in Section 4.2 and lends support for **H2** that the effect of management changes on corporate innovation is more pronounced in firms where VCs have greater power.

4.4 The Effects of Adding New Managers and Removing Existing Managers on Corporate Innovation

As top management changes may include adding new managers as well as removing existing managers (or both), I examine in this section how each of these actions may affect innovation in venture-backed private firms. To do this, I create three separate dummy variables to indicate that only new managers were added (*Add Only*), that only existing managers were removed (*Remove Only*), and that both happened (*Both*), and use them as the main explanatory variables for innovation. I also use two sets of continuous variables, namely, the fraction and the number of managers added and removed, as alternative measures for adding and removing managers.

Panel A of Table 6 report the estimation results using *Add Only*, *Remove Only*, and *Both* as the main explanatory variables. Columns (1)-(4) show that, the coefficients on *Add Only* are positive

[24] Following Wooldrige (2010), I run the first-stage probit regression as shown in regression (5) and compute the predicted probability of a top management change ($\widehat{Mgmt\ Change}$). Then I use $\widehat{Mgmt\ Change}$ and $\widehat{Mgmt\ Change} \times$ *High Power* as instrumental variables for *Mgmt Change* and *Mgmt Change*$\times$*High Power* and conduct an IV (2SLS) analysis. The first-stage F-statistic (Cragg-Donald Wald F statistic) for the weak instrument test is 24.26, which is significantly larger than the critical value suggested in Stock and Yogo (2005).

and significant at the 5% level for almost all the specifications, while the coefficients on *Remove Only* are all insignificant. The coefficients on *Both* are positive and significant at the 10% level for the quantity of innovation but insignificant for the quality of innovation. The differences between coefficients on *Add Only* and those on *Remove Only* or *Both* are statistically significant at the 10% level for the two-year patent counts and patent citations regressions. These results lend support for **H4** but not for **H3**, suggesting that adding new managers to the top management team is the major drive that spurs innovation.

Panel B of Table 6 reports regression results using alternative measures for adding new managers and removing existing managers. Columns (1) and (2) report the effect of the fraction of new managers added as well as the fraction of existing managers removed on two-year patent counts and citations. Columns (3)-(4) report regression results using the log of the number of new managers added and that of existing managers removed as the main explanatory variables.[25] Consistent with the results reported in Panel A, I find that the coefficients on measures for adding managers are significantly positive for all the specifications, while the coefficients on measures for removing managers are much smaller and insignificant. The differences between coefficients on measures for adding new managers and those on measures for removing existing managers are statistically significant for most specifications. The economic magnitude of the effect of adding new managers on corporate innovation is significant as well. For example, a one standard deviation increase in the fraction of managers added (0.214) is associated with 6.6% increase in two-year patents and 5.4% increase in two-year patent citations following management changes.

I then turn to explore the effect of adding new managers as well as removing existing managers on innovation for firms with different VC power. To do this, I interact the three indicator variables for adding new managers, removing existing managers, and both with the dummy variable for greater VC power. I report the results for these interaction tests in Table 7. I find that the interaction term *Add Only* $\times$ *High Power* loads positively and significantly for Columns (1)-(3), which is consistent with the conjecture that bringing in new managers is a source of value addition by VCs and venture-driven management changes are more effective in enhancing corporate innovation if VCs have more power in the firm. The coefficients on the other two interaction terms are almost

[25] Here I use the cumulative two-year patent counts and citations as the only set of dependent variables in order to save space. The regressions using the cumulative three-year patent counts and patent citations yield qualitatively similar results. These results are available from the author upon request.

all insignificant, consistent with my earlier results reported in Table 6 that adding new blood to the management team plays a major role in enhancing innovation. Collectively, my results in this section provide support for my hypothesis **H4**.

4.5 The Background of New Managers and Corporate Innovation

I show in the previous section that adding new managers is the major drive that enhances corporate innovation. In this section, I dig deeper into the profile of each new manager added to the management team and explore how different background of these new managers (in terms of educational and employment experience) may play a role in enhancing corporate innovation. To do this, I search for and read the bios of each new manager in my sample on their personal website, their company's website, LinkedIn, or Bloomberg, etc., and collect information on their educational background and employment history. I then classify all the new managers that were added to the management team into two broad categories: seasoned CEOs or presidents (who have prior experience working as a CEO or president in another company) and managers with a prior technical background (who hold a doctoral degree in a field related to the firm's business, or who were previously engaged in research and development process in another company working as a Chief Technology Officer (CTO) or Chief Innovation Officer (CIO), or who were previously granted patents in a field related to the firm's business). If the new management teams are better at managing and attracting human capital (scientists and engineers) and thus foster innovation activities, I would expect that adding seasoned CEOs to have a positive and significant effect on corporate innovation. If the new management teams are better at generating innovation themselves, I would expect adding people with a prior technical background to have a positive and significant effect on corporate innovation. These two effects are not mutually exclusive and may coexist. To test these implications of the background of new managers on innovation, I estimate the following model:

$$\begin{aligned} Innovation^{(N)} &= \alpha + \beta_1 Ln(Seasoned\ CEOs\ Added)_{i,t} + \beta_2 Ln(Tech\ Mgrs\ Added)_{i,t} \\ &\quad + \delta Add(Dummy)_{i,t} + \gamma Z_{i,t} + Industry + Year + Stage + \epsilon_{i,t}. \end{aligned} \tag{6}$$

In the above regression, *Ln(Seasoned CEOs Added)* is the natural log of one plus the number of managers added to the management team who have prior working experience as a CEO or president in another company. *Ln(Tech Mgrs Added)* is the natural log of one plus of the number of managers with a prior technical background that have been added to the management team. I include the indicator variable for adding new managers (*Add(Dummy)*) so that the coefficients on *Ln(Seasoned CEOs Added)* and on *Ln(Tech Mgrs Added)* capture the incremental effects of adding seasoned CEOs and adding managers with a prior technical background compared to the case of adding managers with other backgrounds. The results for the above regressions are reported in Table 8. I find that adding seasoned CEOs or presidents has a significantly positive effect on the firm's innovation, especially on the quality of innovation. However, adding managers with a prior technical background does not have a significant impact on innovation. The differences between the coefficients on *Ln(Seasoned CEOs Added)* and those on *Ln(Tech Mgrs Added)* are statistically significant at the 10% level for the regressions using the quality of innovation as the dependent variables. Collectively, these findings suggest that the new management teams enhance innovation in venture-backed entrepreneurial firms as they are better at managing resources and human capital, which support my hypothesis **H5** but not **H6**.

4.6 The Effect of Top Management Changes on Corporate Innovation in Different Development Stages

The level of risks faced by venture-backed firms in generating innovation as well as in running their business as a whole varies in different stages. In general, these venture-backed entrepreneurial firms face larger risks in their early stages than in their late stages when they mature. If top management changes do play a significant role in spurring innovation in venture-backed firms as documented earlier, I would expect the positive effect of top management changes on innovation to be stronger in a firm's early stages than in its late stages.

I estimate regression (1) for venture-backed companies in their early stages and in their late stages separately, where *Early Stage* includes "early stage" and "start-up/seed" stages and *Late Stage* includes the "later stage," "acquisition," "expansion," and "acquisition for expansion" stages. I report these results in Panel A of 9 use patent counts and patent citations as the dependent variables, respectively. I find that the effects of management changes on future innovation for ventures in their early stages are all positive and significant (mostly at the 1% level), while the marginal effects in their late stages are all insignificant. The differences of the coefficients on *Mgmt*

Change in the early stage group and in the late stage group are significant mostly at the 10% level. To summarize, my findings support the conjecture that the marginal effect of management changes on innovation is stronger for venture-backed firms in their early stages when they face greater level of risks and difficulties running their businesses than in their late stages when they mature into development.

In Panel B, I investigate the effects of adding new managers as well as removing existing managers on innovation for ventures in the early stages and in the late stages by separately estimating the regressions using *Add Only*, *Remove Dummy*, and *Both* as the main explanatory variables across the above two groups. I find that the effects of adding new managers on future innovation are significantly positive and significantly larger (all at the 5% level) for ventures in their early stages than for ventures in their late stages, while the effects of removing existing managers on innovation for ventures in the early stages are not significant and not statistically different from those for ventures in the late stages. These results are also consistent with my earlier findings that adding new blood to the top management team is the major drive that enhances innovation.

4.7 Mechanism: Inventor Mobility Channel

My evidence so far is consistent with the notion that top management changes in venture-backed firms are likely to be driven by VCs and have positive impacts on future corporate innovation. In this section, I investigate the possible underlying mechanism through which this occurs. As argued earlier, the new management teams may select and allocate resources to higher quality innovation projects, manage innovative assets better, and provide a better environment for inventors (scientists and engineers) to succeed (for example, in the sense of Manso (2011), by creating a more failure-tolerant environment for inventors), all of which may make the firm more attractive to inventors. Thus, one way that management changes may enhance innovation is by being able to hire more inventors to work for the firm (after controlling for the size of investment). To assess the relationship between management changes and the movement of mobile inventors, I test the the following models:

$$Dep\ Var = \alpha + \beta Mgmt\ Change_{i,t} + \gamma Z_{i,t} + Industry \times Year + Stage + Round + \epsilon_{i,t}, \qquad (7)$$

where i indexes firm and t indexes time and N equals two or three. The dependent variables for regression (7) are the two-year (or three-year) net inflow, outflow, and inflow of mobile inventors that have worked for different firms over my sample period of 2002-2010, respectively, which are defined as in Section 3.4. Z is vector of control variables used in prior tests. I include industry-by-year fixed effects to absorb the industry-wide technology shock that may affect the labor markets. I further include financing round fixed effects to account for the possibility that inventors may likely to move to a firm after it obtained VC financing.

Table 10 reports the results for the above regressions. Columns (1)-(3) correspond to regressions using the net inflow, inflow, and outflow of mobile inventors within two years following management changes as the dependent variables, respectively. Columns (4)-(6) use dependent variables that are measured within three years following management changes. Columns (1) and (2) as well as Columns (4) and (5) in Table 10 suggest that management changes are associated with a significantly greater net inflow and inflow of inventors following top management changes; while the association between management changes and the outflow of inventors is much smaller and insignificant. The economic magnitude of the effects of management changes on the net inflow and inflow of inventors is significant as well: for example, Column (1) suggests that top management changes are associated with a 5.7% increase in the net inflow of inventors over the next two years; and Column (4) suggests that top management changes are associated with associated with a 6.2% increase in the net inflow of inventor over the next three years. These findings support my hypothesis **H7**, and suggest that one mechanism through which top management changes enhance corporate innovation is by the new management team attracting more inventors to work for the firms (after controlling for the size of VC investment).

As argued in prior sections, if VCs have more power in the firm, they may be more effective in using top management changes to create value for the firm through the inventor mobility channel. Therefore, I would expect management changes to have a stronger effect on the net inflows of inventors for firms where VCs have greater power. To test this implication, I include the interaction term of management changes and an indicator variable for greater VC power in the above regressions and report the results for these tests in Panel B of Table 10. As shown in Columns (1) and (4), the coefficients on the interaction of *Mgmt Change* and *High Power* are significantly positive, suggesting that the effect of management changes on the net inflow of inventors is especially stronger for firms where VCs have greater power. Further, the effect of management changes on the future inflow of inventors is more pronounced in such firms, while the effect of management changes on the outflow of inventors is insignificant. Overall, my results are consistent with the conjecture that VCs are more effective in using top management changes to enhance innovation through attracting more inventors when they have more power in the firm.

4.8 The Effect of Top Management Changes and Corporate Innovation on Successful Exits

My results thus far have documented a positive relation between top management changes and subsequent corporate innovation. In this section, I investigate the implication of top management changes and corporate innovation on the successful exit of venture-backed firms. Both IPOs and acquisitions are considered as successful exit outcomes in the existing literature (e.g., Hochberg, Ljungqvist, and Lu (2007), Sörensen (2007), and Nahata (2008)). I therefore use the following variables to measure the successful exit of venture-backed firms: (i) *IPO*, a dummy variable equal to one if the venture-backed firm went public within ten years after receiving the first round of VC financing and zero otherwise; (ii) *MA*, a dummy variable equal to one if the venture-backed firm was acquired by another company within ten years after receiving the first round of VC financing and zero otherwise; (iii) *Exit*, a dummy variable equal to one if the venture-backed firm either went public or was acquired by another company within ten years after receiving the first round of VC financing.[26] In my sample, 5% of the venture-backed firms exited through an IPO and 21% of them exited through an acquisition. These statistics are comparable to those documented in the existing literature (e.g., Tian (2011) and Ewens and Marx (2014)). Using the above three measures as the dependent variables, I conduct the following firm-level probit regressions:

$$\begin{aligned} Prob(Successful\ Exit) = \alpha + \beta_1 Ln(Total\ Added) + \beta_2 Ln(Total\ Removed) \\ + \theta Ln(Innovation) + \gamma Z + Industry + \epsilon_i. \end{aligned} \tag{8}$$

In the above regression, *Ln(Total Added)* and *Ln(Total Removed)* are two different measures for

[26] I require an IPO or acquisition to occur within ten years after the first VC financing, as most VC funds typically have a limited life of ten years (although with the possibility of a few years' extension).

top management changes at the firm level, which are defined as the natural log of one plus the total number of managers that have been added to the management team and the natural log of one plus the total number of managers that have been removed from the management team up to the last financing round, respectively. *Ln(Innovation)* is *Ln(Total Patents)* or *Ln(Total Citations)*, which are defined as the natural log of one plus the total number of patents filed by a firm and the natural log of one plus the total adjusted number of citations received by the patents filed by the firm up to the last financing round, respectively. Z is a set of control variables that may affect the exit outcome of venture-backed firms as suggested in the literature, which includes *Ln(VC Investment)* (the natural log of the total investment made by VCs), *Ln(Age)* (the natural log of a firm's age in the last VC financing round), and *VC Syndication* (a dummy variable equal to one if a firm receives VC funding from more than one VC firm at least for one financing round and zero otherwise). I also include industry fixed effects in the above regressions and use robust standard errors.

Table 11 reports the results for the above regressions. Columns (1)-(3) reports the effect of management changes and corporate innovation output on the probability of a venture-backed private firm going public within ten years of receiving the first VC financing round. The regression in Column (1) uses management change measures only as the main explanatory variables. I find that the coefficient on *Ln(Total Added)* is positive and significant, while the coefficient on *Ln(Total Removed)* is insignificant, suggesting that adding new managers has an important impact on the probability of a venture-backed private firm going public. In terms of economic magnitude, Column (1) suggests that a one standard deviation increase in *Ln(Total Added)* is associated with 2.4% increase in the probability of IPO. In the regressions in Columns (2) and (3), I include the patent counts and patent citations as additional explanatory variables, respectively. I find that the both coefficients on patent counts and patent citations are positive and significant at the 5% level. Further, the coefficient on *Ln(Total Added)* becomes less significant and smaller once the innovation variables are included. These results suggest the positive effect of management changes on IPO is likely to be at least partly mediated through enhanced innovation output. In terms of economic magnitude, Columns (2) suggests that a one standard deviation increase in the number of managers added is associated with 2.1% increase in the probability of a venture-backed firm's IPO and a one standard deviation increase in patent counts is associated with 1.6% increase in the probability of IPO. These results also suggest that management changes and corporate innovation have equally important impacts on the probability of an IPO, which is considered as a "gold standard" of venture success.

As reported in Columns (4)-(6), I find that patent counts and patent citations remain significant determinants of the probability of venture-backed firms getting acquired, while neither adding managers nor removing existing managers has a significant effect. In Columns (7)-(9), I find that adding new managers is positively and significantly associated with the probability of a venture-backed firm's exit either through a IPO or an acquisitions. Again, when innovation variables are included, the coefficients on the *Ln(Total Added)* become insignificant, suggesting that the effect of adding new managers on a firm's successful exit is at least partly mediated through innovation. These results suggest that both top management changes (especially adding new blood to the management team) and corporate innovation have a positive impact on the successful exit of venture-backed private firms. Collectively, these results support my hypotheses **H8** and **H9**.

5 Robustness Tests

5.1 Robustness to Controlling for Industry-by-State-by-Year Fixed Effects

Since my instrumental variable analysis makes use of variation at the industry-by-state-by-year level, one concern may be that that industry-by-state-by-year level omitted variables (e.g, a technology shock specific to some states) may affect both management changes and corporate innovation. To alleviate such concerns, I replace the industry and year fixed effects in the baseline models by industry-by-state-by-year fixed effects and re-run these regressions. I report the results for theses regressions in Table 12. For almost all the specifications, I find that the positive effect of management changes on future innovation remains positive and significant, even after controlling for the industry-by-state-by-year fixed effects. The economic magnitude remains significant as well: for example, three-year patent counts increase by 13.3% following management changes, and three-year patent citations increase by 15.2% following top management changes.

5.2 Placebo Test: The Effect of Top Management Changes on Corporate Innovation Generated Prior to Management Changes

To further alleviate the concern that the positive relationship between top management changes and enhanced innovation may be driven by some omitted variables such as a trend of technological development, I therefore conduct a placebo test using a firm's corporate innovation output generated prior to management changes as the dependent variables in this section. If enhanced innovation is indeed caused by management changes rather than drivers such as a trend of technological development, I would expect that management changes to have a significant effect only on innovation generated after management changes, but not on that generated prior to management changes. To test these implications, I estimate the following model:

$$Innovation^{(-N)} = \alpha + \beta Mgmt\ Change_{i,t} + \gamma Z_{i,t} + Industry + Year + Stage + \epsilon_{i,t}, \qquad (9)$$

where $Innovation^{(-N)}$ includes $Patents^{(-N)}$ and $Cites^{(-N)}$, which are defined as the natural log of one plus the number of patents filed in the past N years prior to management changes and the natural log of one plus the total number of citations received by these patents, and N equals 2 and 3. The same set of control variables and fixed effects as in my baseline model (regression (1)) are included in the above models.

I present the results for the above placebo test in Table 13. For all the specifications, top management changes do not have a significant impact on innovation generated prior to top management changes. To summarize, the above results for the placebo test suggest that the positive relation between management changes and enhanced innovation is unlikely to be driven by omitted variables such as a trend of technological development.

5.3 Robustness to Controlling for Lead VC Firm Fixed Effects

Prior literature (e.g., Tian and Wang (2014)) has suggested that VC firm characteristics may affect its project selection ability or preferences and thus the characteristics and quality of the projects that it funded. To alleviate the concern that the relation between management changes and corporate innovation may be driven by VC firm characteristics, I include lead VC firm fixed effects in my baseline models in this section.[27] This helps to control for the effect of any unobservable and time-invariant VC characteristics. If the VC firm's project selection ability or preference (as reflected in the project quality) has a time-invariant component, then including lead VC firm fixed effects will mitigate this impact.

The results of this test are reported in Table 14. Consistent with my earlier results, the coefficients on management changes are significantly positive for almost all the specifications, even after controlling for the lead VC firm fixed effects. This suggests that the positive relation between management changes and enhanced future innovation is not likely to be driven by the unobservable characteristics of VC firms such as project selection ability or preferences.

6 Conclusion

Using a unique hand-collected dataset, I analyze the effect of top management changes on corporate innovation in venture-backed private firms. This is the first paper to establish the causal link between top management changes as a specific action by venture capitalists and product market innovations of their portfolio companies. I find that top management changes are associated with significantly more and higher quality corporate innovation output. Further, my evidence suggests that top management changes in venture-backed private firms are likely to be driven by venture capitalists and that the effect of management changes on innovation is stronger for firms where venture capitalists have more power. These results are consistent with the existing studies suggesting that venture capitalists provide value-addition services beyond providing capital for their portfolio companies through active intervention in recruiting management (see, e.g., Gorman and Sahlman (1989) and Hellmann and Puri (2002)). An instrumental variable analysis making use of a plausibly exogenous shock to the supply of outside managers shows that the above documented relation is causal.

My evidence also suggests that adding new managers has a positive and significant effect on enhancing innovation, while removing existing managers does not. Having established that, I use hand-collected information on educational background and employment history of each new manager and find that adding seasoned CEOs or presidents to the firm's top management team

[27] Following the existing literature (e.g., Hochberg, Ljungqvist, and Lu (2007)), I define the lead VC as the one that makes the largest total investment across all rounds of funding in a venture-backed firm.

(not necessarily as a CEO or president) has a positive and significant effect on innovation, while adding senior managers with a prior technical background does not. Further, I analyze the possible underlying mechanisms through which top management changes may affect corporate innovation in venture-backed private firms and establish that one such mechanism is through new management teams hiring a greater number of inventors and scientists for a given investment size. Finally, I find that top management changes have a positive effect on the probability of a firm's successful exit (especially exit via an IPO) and such an effect is at least partly through enhanced innovation.

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Table 1: Summary Statistics

This table reports the summary statistics for my sample of venture-backed private firms between 2002 and 2010. *Patents*$^{(2)}$ is the natural log of one plus the number of patents filed over the next two years; *Patents*$^{(3)}$ is the natural log of one plus the number of patents filed over the next three years; *Cites*$^{(2)}$is the natural log of one plus the adjusted number of citations received by patents filed over the next two years; *Cites*$^{(3)}$is the natural log of one plus the adjusted number of citations received by patents filed over the next three years. *Management Change* is a dummy variable equal to one for a firm-financing round if there was a change in the composition of the top management team and zero otherwise. *Add (Dummy)* is a dummy variable equal to one for a firm-financing round if new managers were added to the top management team and zero otherwise; *Remove (Dummy)* is a dummy variable equal to one if existing managers were removed from the top management team and zero otherwise. *Add (Fraction)* is the number of new managers added to the top management team divided by the total number of managers on the top management team for a firm-financing round; *Remove (Fraction)* is the number of existing managers removed from the top management team divided by the total number of managers on the top management team. *Add (Raw Number)* is the number of new managers added to the top management team for a firm-financing round; *Remove (Raw Number)* is the number of existing managers removed from the top management team for a firm-financing round. *Ln(VC Investment)* is the natural log of VC investment amount. *Syndicate Size* is the number of investing VCs. *Management Team Size* is the total number of managers on the top management team. *Outside Board Members* is the number of outside board members. *Firm Age* is the age of the venture-backed firm in the financing year since it was founded.

Variable	N	Mean	Stdev	Min	P25	Median	P75	Max
Patents$^{(2)}$	977	0.503	0.801	0.000	0.000	0.000	0.693	3.738
Patents$^{(3)}$	977	0.606	0.911	0.000	0.000	0.000	1.099	3.829
Cites$^{(2)}$	977	0.401	0.800	0.000	0.000	0.000	0.327	4.036
Cites$^{(3)}$	977	0.484	0.906	0.000	0.000	0.000	0.693	4.325
Management Change	977	0.306	0.461	0.000	0.000	0.000	1.000	1.000
Add (Dummy)	977	0.230	0.421	0.000	0.000	0.000	0.000	1.000
Remove (Dummy)	977	0.166	0.372	0.000	0.000	0.000	0.000	1.000
Add (Fraction)	977	0.110	0.214	0.000	0.000	0.000	0.000	0.833
Remove (Fraction)	977	0.122	0.370	0.000	0.000	0.000	0.000	1.000
Add (Raw Number)	977	0.410	0.991	0.000	0.000	0.000	0.000	15.000
Remove (Raw Number)	977	0.257	0.705	0.000	0.000	0.000	0.000	8.000
Ln(VC Investment)	977	8.478	1.230	3.664	7.730	8.613	9.306	12.367
Syndicate Size	977	3.230	1.957	1.000	2.000	3.000	4.000	15.000
Management Team Size	977	2.595	1.615	1.000	2.000	2.000	3.000	18.000
Outside Board Members	977	3.117	1.700	0.000	2.000	3.000	4.000	9.000
Firm Age	977	3.070	2.707	0.000	1.000	3.000	4.000	26.000

Table 2: The Effect of Top Management Changes on Corporate Innovation (Baseline Results)

This table reports the OLS regression results of corporate innovation on top management changes. *Patents*$^{(2)}$ is the natural log of one plus the number of patents filed over the next two years; *Patents*$^{(3)}$ is the natural log of one plus the number of patents filed over the next three years; *Cites*$^{(2)}$ is the natural log of one plus the adjusted number of citations received by patents filed over the next two years; *Cites*$^{(3)}$ is the natural log of one plus the adjusted number of citations received by patents filed over the next three years. *Mgmt Change* is a dummy variable equal to one for a firm-financing round if there was a change in the composition of the top management team and zero otherwise. *Ln(VC Investment)* is the natural log of VC investment amount. *Ln(Syndicate Size)* is the natural log of one plus the number of investing VCs. *Ln(Mgmt Team Size)* is the natural log of one plus the total number of managers on the top management team. Intercept, industry fixed effects (defined at the 2-digit SIC code level), financing year fixed effects, and startup development stage fixed effects are included in all regressions. All standard errors are adjusted for clustering at the industry level and are reported in parentheses below the coefficient estimates. ***, **, and * represent statistical significance at the 1, 5 and 10 percent levels, respectively.

	(1)	(2)	(3)	(4)
VARIABLES	Patents$^{(2)}$	Patents$^{(3)}$	Cites$^{(2)}$	Cites$^{(3)}$
Mgmt Change	0.140***	0.116**	0.117**	0.080
	(0.048)	(0.056)	(0.047)	(0.062)
Ln(VC Investment)	0.169***	0.197***	0.160***	0.179***
	(0.035)	(0.044)	(0.034)	(0.042)
Ln(Syndicate Size)	0.074	0.074	0.058	0.023
	(0.070)	(0.072)	(0.076)	(0.085)
Ln(Mgmt Team Size)	-0.052	0.054	-0.049	0.037
	(0.074)	(0.110)	(0.084)	(0.127)
Observations	743	577	743	577
Adjusted R-squared	0.195	0.177	0.165	0.132
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Stage FE	Yes	Yes	Yes	Yes

Table 3: The Effect of VC Power on the Probability of Top Management Changes

This table reports the probit regression results of the probability of top management changes on measures for VC power. *Mgmt Change* is a dummy variable equal to one for a firm-financing round if there was a change in the composition of the top management team and zero otherwise. *Ln(Outside Board Members)* is the natural log of one plus the number of outside board members. *Fraction of Outside Board Members* is the number of outside board members divided by the total number of board members. *Ln(VC Investment)* is the natural log of VC investment amount. *Ln(Syndicate Size)* is the natural log of one plus the number of investing VCs. *Ln(Mgmt Team Size)* is the natural log of one plus the total number of managers on the top management team. *Ln(Firm Age)* is the natural log of one plus the firm's age in the financing year since it was founded. Intercept, 2-digit SIC industry fixed effects, financing year fixed effects, and startup development stage fixed effects are included in all regressions. All standard errors are adjusted for clustering at the industry level and are reported in parentheses below the coefficient estimates. ***, **, and * represent statistical significance at the 1, 5 and 10 percent levels, respectively.

	(1)	(2)
VARIABLES	Mgmt Change	Mgmt Change
Ln(Outside Board Members)	0.645***	
	(0.185)	
Fraction of Outside Board Members		1.472***
		(0.361)
Ln(VC Investment)	-0.018	-0.021
	(0.037)	(0.034)
Ln(Syndicate Size)	0.241***	0.298***
	(0.093)	(0.092)
Ln(Mgmt Team Size)	0.945***	1.088***
	(0.105)	(0.110)
Ln(Firm Age)	-0.234***	-0.235***
	(0.077)	(0.071)
Observations	955	955
Pseudo R-squared	0.264	0.256
Industry FE	Yes	Yes
Year FE	Yes	Yes
Stage FE	Yes	Yes

Table 4: The Effect of Top Management Changes on Corporate Innovation for Firms with Different VC Power

This table reports the OLS regression results of corporate innovation on the interaction between top management changes and a dummy variable for greater VC power. *Patents*$^{(2)}$ is the natural log of one plus the number of patents filed over the next two years; *Patents*$^{(3)}$ is the natural log of one plus the number of patents filed over the next three years; *Cites*$^{(2)}$ is the natural log of one plus the adjusted number of citations received by patents filed over the next two years; *Cites*$^{(3)}$ is the natural log of one plus the adjusted number of citations received by patents filed over the next three years. *Mgmt Change* is a dummy variable equal to one for a firm-financing round if there was a change in the composition of the top management team and zero otherwise. *High Power* is a dummy variable equal to one if the number of outside board members is above the sample median and zero otherwise. *Ln(VC Investment)* is the natural log of VC investment amount. *Ln(Syndicate Size)* is the natural log of one plus the number of investing VCs. *Ln(Mgmt Team Size)* is the natural log of one plus the total number of managers on the top management team. Intercept, industry fixed effects, financing year fixed effects, and startup development stage fixed effects are included in all regressions. All standard errors are adjusted for clustering at the industry level and are reported in parentheses below the coefficient estimates. ***, **, and * represent statistical significance at the 1, 5 and 10 percent levels, respectively.

	(1)	(2)	(3)	(4)
VARIABLES	Patents$^{(2)}$	Patents$^{(3)}$	Cites$^{(2)}$	Cites$^{(3)}$
Mgmt Change × High Power	0.179***	0.357***	0.158**	0.333***
	(0.052)	(0.084)	(0.075)	(0.100)
Mgmt Change	0.055	-0.076	0.041	-0.096
	(0.057)	(0.093)	(0.071)	(0.088)
High Power	-0.114	-0.151	-0.097	-0.158
	(0.084)	(0.134)	(0.087)	(0.128)
Ln(VC Investment)	0.171***	0.193***	0.161***	0.176***
	(0.037)	(0.047)	(0.035)	(0.044)
Ln(Syndicate Size)	0.083	0.086	0.066	0.036
	(0.072)	(0.072)	(0.079)	(0.086)
Ln(Mgmt Team Size)	-0.047	0.078	-0.044	0.059
	(0.074)	(0.110)	(0.087)	(0.130)
Observations	743	577	743	577
Adjusted R-squared	0.196	0.180	0.165	0.134
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Stage FE	Yes	Yes	Yes	Yes

Table 5: The Effect of Top Management Changes on Corporate Innovation: Instrumental Variable Analysis

Panel A of this table reports the Instrumental Variable (IV/2SLS) regression results of corporate innovation on top management changes. The instrumental variable used is the number of acquisitions made by public firms in the same industry and in the same state as the venture-backed firm multiplied by an index measuring the enforceability of non-compete clauses in that state. Column (1) reports the first-stage probit regression result, i.e., regressing the probability of top management changes on the instrumental variable and other controls. Columns (2)-(5) reports the second-stage results of the IV regressions using the number of patents and total number of citations in the next two and three years as dependent variables, respectively. Panel B reports the second-stage results of the IV regressions for the relation between top management changes, VC power, and corporate innovation. *Patents*$^{(2)}$ is the natural log of one plus the number of patents filed over the next two years; *Patents*$^{(3)}$ is the natural log of one plus the number of patents filed over the next three years; *Cites*$^{(2)}$ is the natural log of one plus the adjusted number of citations received by patents filed over the next two years; *Cites*$^{(3)}$ is the natural log of one plus the adjusted number of citations received by patents filed over the next three years. *Ln(VC Investment)* is the natural log of VC investment amount. *Ln(Syndicate Size)* is the natural log of one plus the number of investing VCs. *Ln(Mgmt Team Size)* is the natural log of one plus the total number of managers on the top management team. *Ln(Outside Board Members)* is the natural log of one plus the number of outside board members. *Ln(Firm Age)* is the natural log of one plus the firm's age in the financing round since it was founded. Intercept, industry by year fixed effects, state by year fixed effects, and startup development stage fixed effects are included in all regressions. All standard errors are adjusted for clustering at the industry level and are reported in parentheses below the coefficient estimates. ***, **, and * represent statistical significance at the 1, 5 and 10 percent levels, respectively.

Panel A: The Effect of Top Management Changes on Corporate Innovation (2SLS Results)

	(1)	(2)	(3)	(4)	(5)
	1st-Stage	2SLS			
VARIABLES	Mgmt Change	Patents$^{(2)}$	Patents$^{(3)}$	Cites$^{(2)}$	Cites$^{(3)}$
Instrument	0.005***				
	(0.001)				
Mgmt Change		0.392***	0.579***	0.487**	0.689***
		(0.127)	(0.159)	(0.203)	(0.238)
Ln(VC Investment)	-0.081	0.177***	0.205***	0.181***	0.204***
	(0.129)	(0.033)	(0.034)	(0.034)	(0.042)
Ln(Syndicate Size)	0.410*	0.147	0.082	0.093	-0.044
	(0.248)	(0.103)	(0.132)	(0.129)	(0.156)
Ln(Mgmt Team Size)	1.062***	-0.001	0.039	-0.033	-0.014
	(0.146)	(0.068)	(0.077)	(0.081)	(0.109)
Ln(Outside Board Members)	1.308**	-0.028	0.033	-0.123	-0.037
	(0.539)	(0.077)	(0.097)	(0.075)	(0.090)
Ln(Firm Age)	-0.648***	0.014	-0.009	-0.044	-0.086
	(0.170)	(0.066)	(0.097)	(0.050)	(0.090)
Observations	743	743	577	743	477
Pseudo R-squared	0.367				
Industry-by-Year FE	Yes	Yes	Yes	Yes	Yes
State-by-Year FE	Yes	Yes	Yes	Yes	Yes
Stage FE	Yes	Yes	Yes	Yes	Yes

Panel B: The Effect of Top Management Changes on Corporate Innovation for Firms with Different VC Power (2SLS Results)

	(1)	(2)	(3)	(4)
VARIABLES	Patents$^{(2)}$	Patents$^{(3)}$	Cites$^{(2)}$	Cites$^{(3)}$
Mgmt Change × High Power	0.407***	0.476***	0.515***	0.564***
	(0.118)	(0.110)	(0.133)	(0.180)
Mgmt Change	0.086	0.252	0.119	0.314
	(0.159)	(0.176)	(0.219)	(0.290)
High Power	-0.030	-0.143	-0.096	-0.199
	(0.060)	(0.113)	(0.100)	(0.175)
Ln(VC Investment)	0.169***	0.199***	0.173***	0.197***
	(0.030)	(0.031)	(0.032)	(0.040)
Ln(Syndicate Size)	0.135	0.071	0.078	-0.057
	(0.097)	(0.129)	(0.124)	(0.158)
Ln(Mgmt Team Size)	0.072	0.083	0.034	0.027
	(0.082)	(0.089)	(0.085)	(0.132)
Ln(Outside Board Members)	-0.048	0.064	-0.120	0.012
	(0.093)	(0.112)	(0.112)	(0.124)
Ln(Firm Age)	0.007	-0.006	-0.051	-0.082
	(0.067)	(0.104)	(0.053)	(0.100)
Observations	743	577	743	577
Industry-by-Year FE	Yes	Yes	Yes	Yes
State-by-Year FE	Yes	Yes	Yes	Yes
Stage FE	Yes	Yes	Yes	Yes

Table 6: The Effect of Adding and Removing Managers on Corporate Innovation

This table reports the OLS regression results of corporate innovation on adding new managers to and removing existing managers from the top management team. Panel A uses three separate dummy variables for adding new managers only, removing managers only, and both adding and removing managers, as the main explanatory variables. Panel B uses the fraction and number of managers added and removed as the main explanatory variables. *Patents*$^{(2)}$ is the natural log of one plus the number of patents filed over the next two years; *Patents*$^{(3)}$ is the natural log of one plus the number of patents filed over the next three years; *Cites*$^{(2)}$ is the natural log of one plus the adjusted number of citations received by patents filed over the next two years; *Cites*$^{(3)}$ is the natural log of one plus the adjusted number of citations received by patents filed over the next three years. *Add Only* is a dummy variable equal to one if new managers were added to the management team for a firm-round and no existing managers were removed, and zero otherwise; *Remove Only* is a dummy variable equal to one if existing managers were removed from the management team for a firm-round but no new managers were added, and zero otherwise; *Both* is a dummy variable equal to one if new managers were added to and existing managers were removed from a firm's management team as well for a firm-round observation, and zero otherwise. *Add (Fraction)* is the number of new managers added to the top management team divided by the total number of managers on the top management team for a firm-financing round; *Remove (Fraction)* is the number of existing managers removed from the top management team divided by the total number of managers on the top management team. *Add (Log Number)* is the natural log of one plus the number of new managers added to the top management team for a firm-financing round; *Remove (Log Number)* is the natural log of one plus the number of existing managers removed from the top management team. *Ln(VC Investment)* is the natural log of VC investment amount. *Ln(Syndicate Size)* is the natural log of one plus the number of investing VCs. *Ln(Mgmt Team Size)* is the natural log of one plus the total number of managers on the top management team. Intercept, industry fixed effects, financing year fixed effects, and startup development stage fixed effects are included in all regressions. All standard errors are adjusted for clustering at the industry level and are reported in parentheses below the coefficient estimates. ***, **, and * represent statistical significance at the 1, 5 and 10 percent levels, respectively.

Panel A: The Effect of Adding and Removing Managers on Innovation

	(1)	(2)	(3)	(4)
VARIABLES	Patents$^{(2)}$	Patents$^{(3)}$	Cites$^{(2)}$	Cites$^{(3)}$
Add Only	0.225**	0.175**	0.200**	0.140
	(0.086)	(0.080)	(0.097)	(0.098)
Both	0.117*	0.105*	0.029	0.028
	(0.061)	(0.060)	(0.098)	(0.095)
Remove Only	0.127	0.107	0.123	0.103
	(0.107)	(0.106)	(0.129)	(0.159)
Ln(VC Investment)	0.158***	0.197***	0.144***	0.170***
	(0.031)	(0.038)	(0.027)	(0.035)
Ln(Syndicate Size)	0.029	0.013	0.016	-0.049
	(0.084)	(0.089)	(0.089)	(0.101)
Ln(Mgmt Team Size)	-0.086	-0.004	-0.076	-0.024
	(0.056)	(0.084)	(0.067)	(0.079)
Observations	743	577	743	577
Adjusted R-squared	0.298	0.308	0.259	0.259
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Stage FE	Yes	Yes	Yes	Yes

Panel B: Using Alternative Measures for Adding and Removing Managers

	(1)	(2)	(3)	(4)
VARIABLES	Patents$^{(2)}$	Cites$^{(2)}$	Patents$^{(2)}$	Cites$^{(2)}$
Add (Fraction)	0.313***	0.253*		
	(0.112)	(0.147)		
Remove(Fraction)	0.066	0.049		
	(0.062)	(0.079)		
Add(Log Number)			0.169**	0.129*
			(0.063)	(0.078)
Remove(Log Number)			0.064	0.036
			(0.113)	(0.129)
Ln(VC Investment)	0.159***	0.146***	0.160***	0.147***
	(0.031)	(0.029)	(0.032)	(0.029)
Ln(Syndicate Size)	0.030	0.015	0.028	0.014
	(0.082)	(0.088)	(0.083)	(0.091)
Ln(Mgmt Team Size)	-0.070	-0.069	-0.105*	-0.092
	(0.052)	(0.062)	(0.057)	(0.061)
Observations	743	743	743	743
Adjusted R-squared	0.297	0.258	0.298	0.258
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Stage FE	Yes	Yes	Yes	Yes

Table 7: The Effect of Adding and Removing Managers on Corporate Innovation for Firms with Different VC Power

This table reports the OLS regression results of corporate innovation on the interaction between measures for adding and removing managers and a dummy variable for greater VC power. *Patents*$^{(2)}$ is the natural log of one plus the number of patents filed over the next two years; *Patents*$^{(3)}$ is the natural log of one plus the number of patents filed over the next three years; *Cites*$^{(2)}$ is the natural log of one plus the adjusted number of citations received by patents filed over the next two years; *Cites*$^{(3)}$ is the natural log of one plus the adjusted number of citations received by patents filed over the next three years. *High Power* is a dummy variable equal to one if the number of outside board members is above the sample median and zero otherwise. *Ln(VC Investment)* is the natural log of VC investment amount. *Add Only* is a dummy variable equal to one if new managers were added to the management team for a firm-round and no existing managers were removed, and zero otherwise; *Remove Only* is a dummy variable equal to one if existing managers were removed from the management team for a firm-round but no new managers were added, and zero otherwise; *Both* is a dummy variable equal to one if new managers were added to and existing managers were removed from a firm's management team as well for a firm-round observation, and zero otherwise. *Ln(VC Investment)* is the natural log of VC investment amount. *Ln(Syndicate Size)* is the natural log of one plus the number of investing VCs. *Ln(Mgmt Team Size)* is the natural log of one plus the total number of managers on the top management team. All standard errors are adjusted for clustering at the industry level and are reported in parentheses below the coefficient estimates. ***, **, and * represent statistical significance at the 1, 5 and 10 percent levels, respectively.

	(1)	(2)	(3)	(4)
VARIABLES	Patents$^{(2)}$	Patents$^{(3)}$	Cites$^{(2)}$	Cites$^{(3)}$
Add Only × High Power	0.345**	0.393**	0.278*	0.306
	(0.159)	(0.189)	(0.169)	(0.204)
Both × High Power	0.136	0.285	0.183	0.402*
	(0.219)	(0.271)	(0.221)	(0.228)
Remove Only × High Power	-0.130	0.371	-0.163	0.189
	(0.193)	(0.351)	(0.244)	(0.362)
Add Only	0.011	-0.063	0.043	-0.032
	(0.097)	(0.127)	(0.094)	(0.128)
Both	-0.007	-0.109	-0.100	-0.261
	(0.144)	(0.201)	(0.151)	(0.189)
Remove Only	0.283	-0.066	0.288	0.076
	(0.190)	(0.333)	(0.225)	(0.336)
High Power	-0.116	-0.151	-0.100	-0.157
	(0.084)	(0.134)	(0.086)	(0.128)
Ln(VC Investment)	0.171***	0.191***	0.160***	0.173***
	(0.037)	(0.046)	(0.035)	(0.042)
Ln(Syndicate Size)	0.086	0.088	0.070	0.039
	(0.072)	(0.071)	(0.078)	(0.086)
Ln(Mgmt Team Size)	-0.052	0.080	-0.045	0.064
	(0.085)	(0.124)	(0.100)	(0.138)
Observations	743	577	743	577
Adjusted R-squared	0.195	0.175	0.165	0.129
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Stage FE	Yes	Yes	Yes	Yes

Table 8: The Effect of Management Team Background on Corporate Innovation

This table reports the effects of adding seasoned CEOs and adding managers with a prior technical background on corporate innovation. *Patents*$^{(2)}$ is the natural log of one plus the number of patents filed over the next two years; *Patents*$^{(3)}$ is the natural log of one plus the number of patents filed over the next three years; *Cites*$^{(2)}$ is the natural log of one plus the adjusted number of citations received by patents filed over the next two years; *Cites*$^{(3)}$ is the natural log of one plus the adjusted number of citations received by patents filed over the next three years. *Ln(Seasoned CEOs Added)* is the natural log of one plus the number of managers who have previously worked as CEOs or presidents in other companies added to the firm's management team. *Ln(Tech Mgrs Added)* is the natural log of one plus the number of managers with a prior technical background added to the firm's management team. *Add (Dummy)* is a dummy variable equal to one for a firm-financing round if new managers were added to the top management team and zero otherwise. *Ln(VC Investment)* is the natural log of VC investment amount. *Ln(Syndicate Size)* is the natural log of one plus the number of investing VCs. *Ln(Mgmt Team Size)* is the natural log of one plus the total number of managers on the top management team. Intercept, industry fixed effects, financing year fixed effects, and startup development stage fixed effects are included in all regressions. All standard errors are adjusted for clustering at the industry level and are reported in parentheses below the coefficient estimates. ***, **, and * represent statistical significance at the 1, 5 and 10 percent levels, respectively.

	(1)	(2)	(3)	(4)
VARIABLES	Patents$^{(2)}$	Patents$^{(3)}$	Cites$^{(2)}$	Cites$^{(3)}$
Ln(Seasoned CEOs Added)	0.244*	0.303*	0.398**	0.497**
	(0.128)	(0.157)	(0.173)	(0.237)
Ln(Tech Mgrs Added)	-0.034	-0.089	-0.080	-0.128
	(0.139)	(0.201)	(0.128)	(0.178)
Add(Dummy)	0.122	0.087	0.050	-0.000
	(0.078)	(0.085)	(0.086)	(0.079)
Ln(VC Investment)	0.163***	0.200***	0.150***	0.174***
	(0.032)	(0.039)	(0.030)	(0.038)
Ln(Syndicate Size)	0.030	0.016	0.016	-0.047
	(0.086)	(0.095)	(0.091)	(0.104)
Ln(Mgmt Team Size)	-0.097*	-0.008	-0.082	-0.027
	(0.051)	(0.091)	(0.050)	(0.060)
Observations	743	577	743	577
Adjusted R-squared	0.298	0.310	0.263	0.266
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Stage FE	Yes	Yes	Yes	Yes

Table 9: The Effect of Top Management Changes on Corporate Innovation in Different Development Stages

Panel A of this table reports the OLS regression results of corporate innovation on top management changes in the early stages versus in the late stages. Panel B reports the effect of adding new managers as well as removing existing managers on corporate innovation in the early stages versus in the late stages. The tests results for the differences between coefficients on management changes in the early stages versus in the late stages are reported at the bottom of each panel. *Early Stage* includes "early stage" and "start-up/seed" stages. *Late Stage* includes the "later stage," "acquisition," "expansion," and "acquisition for expansion" stages. *Patents*$^{(2)}$ is the natural log of one plus the number of patents filed over the next two years; *Patents*$^{(3)}$ is the natural log of one plus the number of patents filed over the next three years; *Cites*$^{(2)}$ is the natural log of one plus the adjusted number of citations received by patents filed over the next two years; *Cites*$^{(3)}$ is the natural log of one plus the adjusted number of citations received by patents filed over the next three years. *Mgmt Change* is a dummy variable equal to one for a firm-financing round if there was a change in the composition of the top management team and zero otherwise. *Add Only* is a dummy variable equal to one if new managers were added to the management team for a firm-round and no existing managers were removed, and zero otherwise; *Remove Only* is a dummy variable equal to one if existing managers were removed from the management team for a firm-round but no new managers were added, and zero otherwise; *Both* is a dummy variable equal to one if new managers were added to and existing managers were removed from a firm's management team as well for a firm-round observation, and zero otherwise. *Ln(VC Investment)* is the natural log of VC investment amount. *Ln(Syndicate Size)* is the natural log of one plus the number of investing VCs. *Ln(Mgmt Team Size)* is the natural log of one plus the total number of managers on the top management team. Intercept, industry fixed effects, and financing year fixed effects are included in all regressions. All standard errors are adjusted for clustering at the industry level and are reported in parentheses below the coefficient estimates. ***, **, and * represent statistical significance at the 1, 5 and 10 percent levels, respectively.

Panel A: The Effect of Top Management Changes on Innovation in Different Stages

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Early	Late	Early	Late	Early	Late	Early	Late
VARIABLES	Patents$^{(2)}$	Patents$^{(2)}$	Patents$^{(3)}$	Patents$^{(3)}$	Cites$^{(2)}$	Cites$^{(2)}$	Cites$^{(3)}$	Cites$^{(3)}$
Mgmt Change (β)	0.212***	-0.061	0.233***	-0.097	0.197***	-0.038	0.179**	-0.015
	(0.052)	(0.132)	(0.066)	(0.210)	(0.054)	(0.160)	(0.078)	(0.194)
Ln(VC Investment)	0.168***	0.224***	0.183***	0.262***	0.175***	0.212***	0.184***	0.241***
	(0.043)	(0.038)	(0.056)	(0.071)	(0.046)	(0.050)	(0.057)	(0.082)
Ln(Syndicate Size)	-0.032	0.175*	-0.067	0.230	-0.068	0.151*	-0.138	0.169
	(0.083)	(0.091)	(0.084)	(0.156)	(0.088)	(0.083)	(0.108)	(0.143)
Ln(Mgmt Team Size)	-0.087	-0.044	0.036	0.018	-0.117	0.003	0.018	-0.010
	(0.115)	(0.106)	(0.155)	(0.187)	(0.151)	(0.140)	(0.198)	(0.203)
Observations	387	343	302	266	387	343	302	266
Adjusted R-squared	0.169	0.216	0.125	0.211	0.130	0.199	0.072	0.164
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Stage FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dif between β	0.273*		0.330*		0.235*		0.193	

Panel B: The Effect of Adding and Removing Managers on Innovation in Different Stages

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Early	Late	Early	Late	Early	Late	Early	Late
VARIABLES	$\text{Patents}^{(2)}$	$\text{Patents}^{(2)}$	$\text{Patents}^{(3)}$	$\text{Patents}^{(3)}$	$\text{Cites}^{(2)}$	$\text{Cites}^{(2)}$	$\text{Cites}^{(3)}$	$\text{Cites}^{(3)}$
Add Only (β_{add})	0.317***	-0.201	0.317***	-0.292	0.355***	-0.216	0.312***	-0.332
	(0.092)	(0.196)	(0.091)	(0.238)	(0.106)	(0.214)	(0.102)	(0.251)
Both	0.092	0.164	0.134	0.125	0.040	0.265	0.055	0.268
	(0.092)	(0.437)	(0.121)	(0.623)	(0.123)	(0.479)	(0.156)	(0.692)
Remove Only	0.190	0.087	0.207	0.226	0.138	0.144	0.096	0.541
	(0.160)	(0.172)	(0.194)	(0.360)	(0.187)	(0.221)	(0.244)	(0.364)
Ln(VC Investment)	0.168***	0.228***	0.182***	0.269***	0.176***	0.217***	0.185***	0.252***
	(0.044)	(0.037)	(0.057)	(0.069)	(0.046)	(0.052)	(0.058)	(0.083)
Ln(Syndicate Size)	-0.027	0.170*	-0.061	0.214	-0.062	0.145*	-0.130	0.143
	(0.083)	(0.088)	(0.090)	(0.147)	(0.090)	(0.077)	(0.117)	(0.133)
Ln(Mgmt Team Size)	-0.100	-0.040	0.022	0.024	-0.144	0.008	-0.017	0.005
	(0.146)	(0.100)	(0.186)	(0.187)	(0.185)	(0.136)	(0.233)	(0.198)
Observations	387	343	302	266	387	343	302	266
Adjusted R-squared	0.170	0.214	0.121	0.209	0.135	0.200	0.071	0.171
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Stage FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Dif between β_{add}	0.518**		0.610**		0.570**		0.644**	

Table 10: The Effect of Top Management Changes on Inventor Mobility

Panel A of this table reports the effect of top management changes on the net inflow, inflow, and outflow of mobile inventors. Panel B reports the effect of top management changes and VC power on the net inflow, inflow, and outflow of mobile inventors. *Inflow*$^{(N)}$ and *Outflow*$^{(N)}$ are defined as the natural log of one plus the total number of inventors that move in and that move out in the next N years following management change, where N equals 2 and 3. *Net Inflow*$^{(N)}$ is defined as the difference between the inflow and outflow of inventors as described above. *High Power* is a dummy variable equal to one if the number of outside board members is above the sample median and zero otherwise. *Ln(VC Investment)* is the natural log of VC investment amount. *Ln(Syndicate Size)* is the natural log of one plus the number of investing VCs. *Ln(Mgmt Team Size)* is the natural log of one plus the total number of managers on the top management team. Intercept, industry by year fixed effects, startup development stage fixed effects, and financing round fixed effects are included in all regressions. All standard errors are adjusted for clustering at the industry level and are reported in parentheses below the coefficient estimates. ***, **, and * represent statistical significance at the 1, 5 and 10 percent levels, respectively.

Panel A: The Effect of Top Management Changes on the Net Inflow, Inflow, and Outflow of Inventors

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Net Inflow$^{(2)}$	Inflow$^{(2)}$	Outflow$^{(2)}$	Net Inflow$^{(3)}$	Inflow$^{(3)}$	Outflow$^{(3)}$
Mgmt Change	0.057***	0.056***	-0.001	0.062*	0.062*	-0.000
	(0.018)	(0.019)	(0.001)	(0.034)	(0.035)	(0.002)
Ln(VC Investment)	0.052**	0.055**	0.004	0.074***	0.079***	0.005
	(0.019)	(0.021)	(0.003)	(0.025)	(0.027)	(0.003)
Ln(Syndicate Size)	0.033	0.034	0.001	0.049	0.050	0.001
	(0.036)	(0.038)	(0.003)	(0.057)	(0.059)	(0.005)
Ln(Mgmt Team Size)	-0.024	-0.022	0.002	0.003	0.005	0.002
	(0.061)	(0.060)	(0.006)	(0.095)	(0.094)	(0.007)
Observations	743	743	743	577	577	577
Adjusted R-squared	0.112	0.139	0.201	0.129	0.152	0.195
Industry-by-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Stage FE	Yes	Yes	Yes	Yes	Yes	Yes
Round FE	Yes	Yes	Yes	Yes	Yes	Yes

Panel B: The Effect of Top Management Changes and VC Power on the Net Inflow, Inflow, and Outflow of Mobile Inventors

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Net Inflow$^{(2)}$	Inflow$^{(2)}$	Outflow$^{(2)}$	Net Inflow$^{(3)}$	Inflow$^{(3)}$	Outflow$^{(3)}$
Mgmt Change × High Power	0.135***	0.113**	-0.022	0.124**	0.095	-0.029
	(0.039)	(0.046)	(0.024)	(0.057)	(0.064)	(0.031)
Mgmt Change	-0.027	-0.018	0.009	-0.027	-0.013	0.013
	(0.030)	(0.026)	(0.012)	(0.059)	(0.053)	(0.017)
High Power	-0.052	-0.052	-0.001	-0.038	-0.039	-0.001
	(0.037)	(0.038)	(0.004)	(0.051)	(0.053)	(0.005)
Ln(VC Investment)	0.051***	0.055***	0.004	0.072***	0.078***	0.006*
	(0.018)	(0.020)	(0.003)	(0.025)	(0.027)	(0.003)
Ln(Syndicate Size)	0.029	0.030	0.001	0.037	0.038	0.000
	(0.036)	(0.037)	(0.004)	(0.052)	(0.054)	(0.005)
Ln(Mgmt Team Size)	-0.015	-0.015	-0.000	0.013	0.012	-0.000
	(0.058)	(0.058)	(0.004)	(0.090)	(0.090)	(0.005)
Observations	743	743	743	577	577	577
Adjusted R-squared	0.119	0.143	0.209	0.133	0.153	0.204
Industry-by-Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Stage FE	Yes	Yes	Yes	Yes	Yes	Yes
Round FE	Yes	Yes	Yes	Yes	Yes	Yes

Table 11: The Effect of Top Management Changes and Corporate Innovation on the Successful Exit of Venture-Backed Private Firms

This table reports the firm-level probit regression results of the probability of the successful exit of venture-backed firms on top management changes and corporate innovation output generated up to the last financing round. *IPO* is a dummy variable equal to one if the firm exited via an initial public offering within ten years of the first financing round and zero otherwise. *MA* is a dummy variable equal to one if the venture-backed firm exited via an acquisition within ten years of the first financing round and zero otherwise. *Exit* is a dummy variable equal to one if the venture-backed firm exited via either an initial public offering or an acquisition within ten years of the first financing round and zero otherwise. *Ln(Total Added)* is the natural log of one plus the total number of managers that have been added to the firm's management team up to the last financing round. *Ln(Total Removed)* is the natural log of one plus the total number of managers that have been removed from the firm's management team up to the last financing round. *Ln(Total Patents)* is the natural log of one plus the total number of patents filed by the venture-backed firm up to the last financing round. *Ln(Total Citations)* is the natural log of one plus the adjusted total number of citations received by all the patents filed by the venture-backed firms up to the last financing round. *Ln(VC Investment)* is the natural log of the VC investment amount. *Ln(Age)* is the natural log of the age of the firm in the last VC financing round. *VC Syndication* is a dummy variable equal to one if a firm is backed by more than one VC firm in any financing round and zero otherwise. Intercept and industry fixed effects are included in all regressions. Robust standard errors are reported in parentheses below the coefficient estimates. ***, **, and * represent statistical significance at the 1, 5 and 10 percent levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
VARIABLES	IPO	IPO	IPO	MA	MA	MA	Exit	Exit	Exit
Ln(Total Added)	0.470**	0.442*	0.443*	0.113	0.088	0.087	0.252*	0.223	0.222
	(0.237)	(0.236)	(0.236)	(0.144)	(0.144)	(0.145)	(0.138)	(0.139)	(0.139)
Ln(Total Removed)	-0.142	-0.146	-0.128	-0.112	-0.124	-0.119	-0.140	-0.154	-0.149
	(0.275)	(0.280)	(0.276)	(0.158)	(0.161)	(0.161)	(0.155)	(0.158)	(0.158)
Ln(Total Patents)		0.226**			0.156*			0.190**	
		(0.114)			(0.087)			(0.086)	
Ln(Total Citations)			0.208**			0.142**			0.178**
			(0.094)			(0.071)			(0.070)
Ln(VC Investment)	0.595***	0.569***	0.572***	0.194***	0.170**	0.174**	0.316***	0.286***	0.291***
	(0.177)	(0.182)	(0.182)	(0.068)	(0.070)	(0.070)	(0.071)	(0.072)	(0.072)
Ln(Age)	0.097	0.115	0.116	-0.013	-0.022	-0.019	0.025	0.018	0.021
	(0.106)	(0.106)	(0.105)	(0.097)	(0.098)	(0.098)	(0.089)	(0.089)	(0.088)
VC Syndication	-0.649	-0.633	-0.686	0.292	0.312	0.280	0.140	0.163	0.124
	(0.567)	(0.584)	(0.597)	(0.283)	(0.277)	(0.280)	(0.279)	(0.272)	(0.277)
Observations	422	422	422	422	422	422	422	422	422
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Pseudo R-squared	0.256	0.279	0.284	0.054	0.061	0.063	0.078	0.086	0.091

Table 12: Robustness Test: Controlling for Industry-by-State-by-Year Fixed Effects

This table reports the OLS regression results of corporate innovation on top management changes controlling for industry-by-state-by-year fixed effects. $Patents^{(2)}$ is the natural log of one plus the number of patents filed over the next two years; $Patents^{(3)}$ is the natural log of one plus the number of patents filed over the next three years; $Cites^{(2)}$ is the natural log of one plus the adjusted number of citations received by patents filed over the next two years; $Cites^{(3)}$ is the natural log of one plus the adjusted number of citations received by patents filed over the next three years. *Mgmt Change* is a dummy variable equal to one for a firm-financing round if there was a change in the composition of the top management team and zero otherwise. *Ln(VC Investment)* is the natural log of VC investment amount. *Ln(Syndicate Size)* is the natural log of one plus the number of investing VCs. *Ln(Mgmt Team Size)* is the natural log of one plus the total number of managers on the top management team. Intercept, industry-by-state-by-year fixed effects, and startup development stage fixed effects are included in all regressions. All standard errors are adjusted for clustering at the industry level and are reported in parentheses below the coefficient estimates. ***, **, and * represent statistical significance at the 1, 5 and 10 percent levels, respectively.

	(1)	(2)	(3)	(4)
VARIABLES	$Patents^{(2)}$	$Patents^{(3)}$	$Cites^{(2)}$	$Cites^{(3)}$
Mgmt Change	0.137*	0.133**	0.119	0.152**
	(0.076)	(0.060)	(0.098)	(0.052)
Ln(VC Investment)	0.129***	0.191***	0.132***	0.172***
	(0.025)	(0.033)	(0.029)	(0.043)
Ln(Syndicate Size)	0.157	0.145	0.103	0.025
	(0.114)	(0.145)	(0.148)	(0.187)
Ln(Mgmt Team Size)	0.111	0.263**	0.098	0.209*
	(0.107)	(0.118)	(0.087)	(0.104)
Observations	743	577	743	577
Adjusted R-squared	0.154	0.186	0.124	0.137
Industry-by-Year-by-State FE	Yes	Yes	Yes	Yes
Stage FE	Yes	Yes	Yes	Yes

Table 13: Placebo Test: The Effect of Top Management Changes on Corporate Innovation Generated Prior to Top Management Changes

This table reports the OLS regression results of corporate innovation generated over the past two or three years on top management changes. $Patents^{(-2)}$ is the natural log of one plus the number of patents filed in the past two years prior to management change; $Patents^{(-3)}$ is the natural log of one plus the number of patents filed in the past three years prior to management change; $Cites^{(-2)}$ is the natural log of one plus the adjusted number of citations received by patents filed in the past two years prior to management change; $Cites^{(-3)}$ is the natural log of one plus the adjusted number of citations received by patents filed in the past three years prior to management change. *Mgmt Change* is a dummy variable equal to one for a firm-financing round if there was a change in the composition of the top management team and zero otherwise. *Ln(VC Investment)* is the natural log of VC investment amount. *Ln(Syndicate Size)* is the natural log of one plus the number of investing VCs. *Ln(Mgmt Team Size)* is the natural log of one plus the total number of managers on the top management team. Intercept, industry fixed effects, financing year fixed effects, and startup development stage fixed effects are included in all regressions. All standard errors are adjusted for clustering at the industry level and are reported in parentheses below the coefficient estimates. ***, **, and * represent statistical significance at the 1, 5 and 10 percent levels, respectively.

	(1)	(2)	(3)	(4)
VARIABLES	$Patents^{(-2)}$	$Patents^{(-3)}$	$Cites^{(-2)}$	$Cites^{(-3)}$
Mgmt Change	0.029	0.059	0.025	0.055
	(0.046)	(0.057)	(0.038)	(0.042)
Ln(VC Investment)	0.116***	0.122***	0.122***	0.129***
	(0.022)	(0.022)	(0.022)	(0.021)
Ln(Syndicate Size)	0.086	0.087	0.075	0.075
	(0.054)	(0.061)	(0.051)	(0.058)
Ln(Mgmt Team Size)	0.052	0.055	0.040	0.035
	(0.058)	(0.065)	(0.066)	(0.076)
Observations	976	976	976	976
Adjusted R-squared	0.165	0.173	0.125	0.138
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Stage FE	Yes	Yes	Yes	Yes

Table 14: Robustness Test: Controlling for Lead VC Firm Fixed Effects

This table reports the OLS regression results of corporate innovation on top management changes controlling for the lead VC firm fixed effects. *Patents*$^{(2)}$ is the natural log of one plus the number of patents filed over the next two years; *Patents*$^{(3)}$ is the natural log of one plus the number of patents filed over the next three years; *Cites*$^{(2)}$ is the natural log of one plus the adjusted number of citations received by patents filed over the next two years; *Cites*$^{(3)}$ is the natural log of one plus the adjusted number of citations received by patents filed over the next three years. *Mgmt Change* is a dummy variable equal to one for a firm-financing round if there was a change in the composition of the top management team and zero otherwise. *Ln(VC Investment)* is the natural log of VC investment amount. *Ln(Syndicate Size)* is the natural log of one plus the number of investing VCs. *Ln(Mgmt Team Size)* is the natural log of one plus the total number of managers on the top management team. Intercept, lead VC firm fixed effects, industry fixed effects, financing year fixed effects, and startup development stage fixed effects are included in all regressions. All standard errors are adjusted for clustering at the industry level and are reported in parentheses below the coefficient estimates. ***, **, and * represent statistical significance at the 1, 5 and 10 percent levels, respectively.

	(1)	(2)	(3)	(4)
VARIABLES	Patents$^{(2)}$	Patents$^{(3)}$	Cites$^{(2)}$	Cites$^{(3)}$
Mgmt Change	0.219***	0.267**	0.180**	0.222
	(0.064)	(0.111)	(0.075)	(0.155)
Ln(VC Investment)	0.119**	0.209**	0.113**	0.198*
	(0.056)	(0.087)	(0.053)	(0.103)
Ln(Syndicate Size)	0.118	0.072	0.079	-0.006
	(0.142)	(0.233)	(0.141)	(0.278)
Ln(Mgmt Team Size)	-0.068	0.008	-0.067	-0.011
	(0.187)	(0.194)	(0.155)	(0.161)
Observations	722	557	722	557
Adjusted R-squared	0.400	0.371	0.328	0.265
Lead VC Firm FE	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Stage FE	Yes	Yes	Yes	Yes