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Venture Capitalists in Mature Public Firms

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ABSTRACT

Using data on the backgrounds of board members of S&P companies, we show that venture capitalists (VCs) play an important role in mature public firms long after their initial public offering (IPO). Almost one-third of mature public companies have at least one VC director on their board. VC presence on the board is not limited to mature companies that were VC-backed at the time of their IPO – over one-third of mature firms with VC directors were not VC-backed at the time of their IPO. Appointments of VC directors to the board are followed by increases in R&D intensity, innovation output, and greater deal activity with other VC-backed firms. VC director appointments are associated with positive announcement returns and are followed by an improvement in operating performance. Finally, firms experience higher announcement returns from acquisitions of VC-backed targets following the appointment of a VC director to the board. Our results show that in addition to their function as providers of finance, monitoring and advice for small private firms, VCs play a significant role in mature public firms as well. Hence, we illustrate a much broader role for VCs than has been established in the literature.

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1. Introduction

Venture capitalists (VCs) have long been recognized as an important source of capital to meet the financing needs of entrepreneurs. A vast literature documents the importance of VCs in the financing and growth of small and private entrepreneurial firms. VCs provide advice and support to small entrepreneurial start-ups (Gompers (1995) and Lerner (1995)), help with the professionalization of the management team (Hellmann and Puri (2002)), exercise monitoring and corporate governance (Kaplan and Stromberg (2003) and (2004), Lerner (1994)), and foster innovation (Hellmann and Puri (2000) and Kortum and Lerner (2000)).

Our understanding of the role of VCs beyond the initial growth stage of firms, is however, very limited. Much of the evidence on the role of VCs in public firms comes from studies at the time of their initial public offering (IPO). For example, Barry, Muscarella, Peavy and Vetsuypens (1990) find that IPO firms with higher quality VCs are less underpriced than IPO firms with lower quality VCs and argue this is due to the monitoring and certification roles of higher quality VCs. Similar results are shown by Megginson and Weiss (1991) who study VC-backing and IPO underpricing. Baker and Gompers (2003) analyze the effect of VCs on board size and composition at the time of the IPO and show that VC-backed companies have better performing boards of directors and these boards are related to better post-IPO performance. Brav and Gompers (1997) study the stock returns of IPO firms and show that VC-backed firms do not suffer from post-IPO underperformance. Hochberg (2011) finds that VC-backed firms have better corporate governance at the time of their IPO. Although these papers focus on different dimensions of VC involvement in public companies, they all have one feature in common: they analyze the effects of VC involvement for newly public firms around the IPO. We are unaware of research on what role, if any,

VCs perform in mature public companies beyond their IPO years. Though there are anecdotal accounts that VCs promote innovation in mature firms[1], to the best of our knowledge, ours is the first systematic study about VCs in mature firms.

We investigate the presence and role of VCs in mature public companies and show that VCs serve on the boards of public companies long after their IPO. Based on a hand-collected dataset on board members of S&P 1500 companies, we show that 30.5% of firms have directors with a background as a VC prior to their appointment on the board. For these companies, VC directors are not a remnant of their pre-IPO board composition since the median firm in our sample has been public for 17 years. The presence of VCs on the boards of these mature companies is also not a direct outcome of VC-backing at the time these firms went public – 35% of firms in our sample with VC directors were not VC-backed at the time of their IPO. In addition, of the companies that were VC-backed at the IPO, almost half of them have VC directors from a VC firm that is different from the one that backed the firm at the IPO. Thus, VCs play a role in mature companies that is not a direct outcome of their pre-IPO involvement in these companies.

We postulate that VC directors bring specific expertise to the board that is valuable to firms pursuing certain types of investment policies. We focus on investment decisions, because unlike young start-ups where VCs play an important financing role, the mature firms in our sample have access to a broad range of financing options including public equity and debt markets. Given the experience of VCs in evaluating new products, technologies, and other innovation intensive activities, we argue that VC directors are likely to be particularly valuable for pursuing investments in such knowledge specific and intangible assets.

[1] See for example, Glaxo Tries Biotech Model to Spur Drug Innovations, Wall Street Journal, July 1, 2010.

We show that the presence of VC directors on the board is strongly associated with greater innovation activity by mature firms. We use three measures of innovation activity – research and development (R&D) expenditures, the number of patents that a firm obtains, and the impact of its patents measured by their citation count. We find that firms with VC directors display higher levels of innovation using all three measures. In addition, the presence of a VC director on the board of a mature firm increases the likelihood that the firm acquires a VC-backed firm, establishes strategic alliances with other VC-backed firms, and undertakes corporate venture capital (CVC) investment in VC-backed entrepreneurial start-ups. Chesbrough (2002) and Dushnitsky and Lenox (2005, 2006) argue that CVC investments and strategic alliances are an important source of innovation for mature firms. Robinson (2008) shows that strategic alliances are valuable for established firms for undertaking projects with high risk and growth potential. Thus, our results imply the presence of VC directors at mature firms is associated with higher firm investment in innovative and entrepreneurial start-ups through strategic alliances and CVC.

There are three potential explanations for the association between VC directors and firm innovation that we find. First, the presence of VC directors helps firms become more innovative because VC directors bring specific expertise to the board allowing for a better evaluation of its innovation related initiatives. Second, VC directors may self-select themselves onto boards of R&D intensive and innovative firms. Such self-selection may occur if VCs derive benefits from enhanced personal visibility in the business world, generating more attractive exit channels for their investments in start-up firms, or from creating synergies with mature firms and the start-ups in their own portfolio. Self-selection may also arise if VC directors are invited to serve on boards of mature public firms that are embarking on extensive R&D and innovation activities. Third, the association between VC directors and innovation may be due to the presence of unobserved factors such as the firm's network with local VC firms that affect both its R&D and innovation output as well as the presence of VCs on the board.

In order to understand causality, we exploit the time series variation in board composition in our sample. We study the appointments of new VC directors to the board and examine changes in R&D intensity and innovation output around these appointments. We find that firms become more R&D intensive and more innovative following the arrival of new VC directors. A similar analysis around the departure of VC directors from the board shows that firms exhibit a significant reduction in their innovation outcomes when VC directors leave the board. These results cast doubt that our results are driven by VC directors self-selecting onto the boards of R&D intensive and innovative firms. Under a selection effect, we would expect appointments of VC directors to occur at firms that were already R&D intensive and innovative but not to be associated with increases in these activities. Even if firms appoint VC directors in anticipation of ramping up their R&D and innovation, our results suggest a value-additive role for VC directors in such situations since firms would only make these appointments if they perceive benefits from doing so.

One concern with our results relates to unobserved variables that may affect both the decision of firms to appoint VC directors as well as their decision to pursue greater R&D and innovation. For example, geography may play a role because R&D intensive and innovative firms may choose to locate in regions that have a high density of VCs. In addition, firms located in areas with high VC density may be more likely to have VC directors on the board, consistent with the idea that the local supply of directors matters for board composition of local firms. In cross-sectional tests, we find that the association between VC directors and firm innovation is robust to the inclusion of the regional density of VCs in our regressions. Further, to the extent that the local network of VCs or other unobserved factors are time-invariant, they cannot explain the time-series variation in R&D and innovation activity we document around VC director appointments.

A more sophisticated challenge arises with respect to the possibility of time-varying unobserved variables. It is possible that an unobserved factor "switches on" at exactly the same time as the VC director appointment and the firm's increase in its R&D and innovation output. To assess this possibility, we exploit the variation in the ties that firms have to the local network of VCs using the regional density of VCs in the area. If network effects are responsible for VC director appointments and the concurrent increases in firm innovation, we expect their role to be more important when the network is strong – i.e. for firms located in high VC density areas. However, we find that positive relation between VC director appointments and firm innovation is driven primarily by firms located in low VC density areas rather than those located in high VC density areas. This result is hard to explain by network effects or some other unobserved factor switching on at exactly the same time as VC director appointments and firm innovation since, a priori, there is no reason such switching on should occur only for firms in low VC density areas. Rather, this result is more consistent with a causal interpretation where VC directors help improve R&D and innovation for firms that have limited access to local VC talent and expertise and hence benefit from the innovation specific human capital provided by VC directors.

The effect of VC directors on R&D expenses and innovation activity of mature firms is economically important. The appointment of a VC director to the board is followed by an increase of 1.85% in R&D expenditures as a percentage of firm market value. Given that the mean R&D expenditure as a percentage of firm market value is 2.33% in our sample, this effect is economically sizeable. The economic effect of VC directors on the productivity of R&D measured as patenting activity is also substantial. We estimate that adjusted for technology and year effects, the number of patents obtained by a firm in a year is 8.6 higher after VC directors are appointed to the board. In addition, the number of future citations received per year by the patents is 7.7 higher after VC directors join the board. Since innovation is one of the primary engines for firm growth, these results suggest that having VC directors on a firm's board is an important mechanism for generating growth in mature companies. In recent work,

Aghion, Van Reenen and Zingales (2009) document that institutional ownership in publicly traded companies is positively related to innovation output measured by cite-weighted patents. Our paper illustrates another channel through which corporate governance structure is linked to the nature of innovation in public companies.

We conduct three additional sets of tests for direct evidence of whether the specific human capital of VC directors helps create value for mature firms. First, we examine the cumulative abnormal announcement returns from M&A activity before and after the appointment of VC directors. We find that following a VC director appointment to the board, acquisitions of VC-backed start-ups generate greater announcement returns than prior to the VC director appointment. Second, we examine whether the operating performance of firms changes around appointments of VC directors and find that such appointments are followed by a significant improvement. Third, we conduct an event study analysis of all new director appointments to the boards of mature firms. We find that announcements of VC director appointments are associated with significantly positive abnormal returns averaging 0.30%, but that abnormal returns around announcements of non VC directors are not significantly different from zero.

These results suggest that VC directors have a meaningful effect on the innovation activities of mature firms and that our results cannot be explained as purely the outcome of selection effects or of unobserved variables. We believe the event study results on director appointments are helpful in this regard because under self-selection, the appointment of a VC director should not convey meaningful information about innovation activity. In addition, we find that the appointment of a VC director leads to a greater abnormal announcement return for firms with lower R&D intensity. These results once again favor the interpretation that the announcement signals a shift in innovation activity and suggest that investors recognize the benefits of VC directors for mature firms, especially for less R&D and innovation intensive firms.

Our paper illustrates that VCs' role in financing and promoting innovation and entrepreneurial activity is not limited to small private firms only. VCs also serve on the boards of mature public firms long time after their IPO and affect their R&D and innovation activity. Since directors typically are not involved in the day to day operations of the firm, we believe our results suggest that VC directors help boards better evaluate the merits of pursuing greater R&D and innovation and set the strategic direction for its innovation related investments. Consistent with this view, we find that VC directors also promote the acquisition of and formation of strategic relationships with VC-backed entrepreneurial start-ups. These effects of VC directors are more important for firms located in areas with low VC densities, indicating that the presence of VCs on the board provides a substitute channel for firms to obtain innovation related expertise when their ties to local VC networks are weak. Given that promoting innovation and identifying new growth opportunities is one of the most important challenges faced by mature firms, our results emphasize that mature firms benefit from the expertise, human capital and networks of VCs in order to become more innovative. Thus, VCs appear to have a much broader economic impact on the growth of companies than just their effect on younger and start-up ventures.

Our paper is also related to the literature on the optimal composition of corporate boards. We illustrate a specific channel through which board expertise affects a firm's investment policy. Though providing expertise has long been identified as an important role of corporate boards (Fama and Jensen (1983)), much of the literature has focused on the monitoring role of directors. Prior work has focused on how the financial expertise of bankers on the board affects financing arrangements (Guner, Malmendier and Tate (2008)) but our evidence suggests a wider role for board expertise.

The rest of the paper is organized as follows. In Section 2, we describe our sample and present some descriptive statistics. In Section 3, we analyze R&D and innovation activity of our sample of firms based on the arrival of a VC director to their board. In Section 4, we analyze the effect of VC directors on

the firm's M&A activity involving VC-backed firms. In Section 5, we investigate the change in the operating performance of a firm after the appointment of a VC director to the board. In Section 6, we conduct an event study analysis for VC director appointments. Section 7 concludes.

2. Data

Our director data come from Investor Responsibility Research Center (IRRC) which provides information on directors of S&P 1500 firms from 1996 onwards. The IRRC database reports each director's primary employment, committees they serve on, their board affiliations, shares held and total voting power. Our sample covers public U.S. companies from 1998 to 2006. [2]

There are a total of 2,325 unique firms and 21,888 unique directors covered in IRRC database from 1998 to 2006. We exclude utilities and financials from our sample since they operate in highly regulated industries. To avoid studying the role of VCs at the time of the IPO, we drop a small number of firms that enter the IRRC database in the year of their IPO or for which the IPO year is not available. This leaves us with a final sample of 1,700 firms and 15,958 directors, forming a panel dataset over nine years covering 9,249 firm-years and 82,688 director-years.

In order to identify VC directors, we employ a two-step search. In the first step, we search for keywords that might define a VC firm in four different employment related data items provided by IRRC for each individual director.[3] The employment related data items that we search for are the primary company name, primary employment category, other employment title, and type of services for each director. If at least one of the keywords we search for is available in any of these data items, we record

[2] Our sample period starts in 1998 since this is the first year IRRC database collects primary employment data of directors – the main data item we need for our analysis. We end our sample period in 2006 since Institutional Shareholder Services (ISS) acquired IRRC in 2005 and changed the methodology to collect governance data in 2007 to follow ISS specifications. Since this change from year 2007 had a significant impact on the governance data, the time series of variables provided after 2007 are not necessarily comparable to the previous data years before 2007.

[3] The keywords that we search for are: Venture, capital, partner, fund, investor, angel, finance, financial, and management.

that director as a possible candidate for being a VC director. In the second step, we hand-collect biographical information from proxy statements of those board members identified as possible VC directors in the first step. Specifically, we obtain information about their professional backgrounds and check whether they work for a firm that is registered as a VC firm in the VentureXpert database in the Securities Data Company (SDC) database. We include only VC firms that are in the VentureXpert database to avoid counting directors that may self-describe themselves as a VC based on their experience as a private investor but who may lack the skills and network associated with working at a VC firm. Using this second step, we identify 634 unique VC directors working in 516 different VC firms. We denote these as *VC directors* and the remaining directors as *non-VC directors*.[4]

Of the 82,688 director-years in the sample, 3,886 represent those with VC directors, implying that VC directors constitute approximately 4.7% of the pool of corporate directors in the sample. Of the 9,249 firm-years in the sample, 2,840 are classified as those where a VC director sits on the board. Hence, on average, 30.7% of firms in a given year have VC directors on the board. The proportion of firms with VC directors is fairly stable during our sample period, ranging from a low of 28.2% in 1998 to a high of 32.1% in 2002. When a VC director is present, the average (median) number of VC directors is 1.36 (1), indicating that on a typical board only one VC director is present. In 11.5% of the firms in our sample, there are two or more VC directors on the board. Based on the standard taxonomy of inside, gray, and independent directors, 82% of the VC directors can be classified as independent directors.

How do the VCs get on the board of our sample of mature public firms? One possibility is that VCs obtain their board seat when one of their portfolio companies gets acquired by a mature firm. This does not, however, appear to be a common route to getting on the board of a mature firm for a VC. Based on an extensive search of public news and company press releases around VC director appointments, we

[4] In our data collection process, we distinguish between VC firms and private equity firms and do not classify private equity professionals as VC directors in our analysis.

find that in only 6.45% of appointments do the news releases identify the appointment as being linked to an acquisition or related transaction with a firm in the VC firm's portfolio. In the remaining 93.55% cases, the news releases typically emphasize the experience and expertise of the VC director and indicate the appointment to be part of the regular director selection process.

Panel A of Table 1 shows that firms with VC directors are younger and they have been public for a shorter time period than firms with no VC directors.[5] Even though they are comparatively younger, firms with VC directors are, on average, 25.4 years old and have been public for almost 20 years. The median firm with VC directors has been public for 13 years.[6]

We examine whether firms with VC directors were VC-backed at the time of their IPO. We define an indicator variable that takes the value of one for firms that were VC-backed at the time of their IPO, and zero otherwise.[7] This indicator variable has an average value of 0.65 for firms with VC directors and 0.32 for firms with no VC directors, implying that firms with VC directors are roughly twice as likely to have been VC-backed at the time of their IPO. We find that only 63.1% of our sample firms which were VC-backed at the time of their IPO have VC directors as mature public firms. Thus, although firms which were VC-backed at the IPO are more likely to have a VC director on their board, being VC-backed at the IPO does not always result in a firm having VC directors on the board later in its life as a public company.

[5] The company founding dates are obtained from Jay Ritter's website, and are available for 43% of our sample firms. Data on IPO dates come from Securities Data Company (SDC)'s New Issues database from 1970 onwards. For firms that went public before 1970, we use the first trading date in CRSP as the IPO date.

[6] The 5th percentile of the distribution for the number of years a firm has been public is 4 years in our sample indicating that the vast majority of the sample firms have been public for several years. 1.2% of firms in the sample have been public for less than three years. Excluding these firms from the sample provides qualitatively similar results.

[7] The data on VC backing at the time of the IPO come from SDC's New Issues database and are reported in SDC starting from year 1970 on. These data are available for 48% of our sample firms.

Firms that are VC-backed at the time of the IPO do not always retain their original VCs on the board when they become mature companies. We track the affiliation of each VC director and compare it to the identity of the VC investors that backed the firm at its IPO. Since the affiliation of VC directors sometimes differs over time due to job changes by VCs, we search the entire employment history of VC directors to see if they were affiliated with the IPO VC at the time of the IPO. We find that such job changes among VC directors are relatively uncommon. Incorporating job changes among VC directors, we find that of the 63.1% of firms which were VC-backed at the IPO and have VC directors, only 39% have their original VCs as directors. In the remaining 24.1% of the firms, the VC directors are different VC investors than the original VCs at the IPO stage. Thus, a substantial fraction of the firms which were VC-backed at their IPO acquire VC directors from VC investors that are different from the original VCs backing the firm at the pre-IPO stage. One explanation for this pattern is that VC-backed IPO firms have stronger ties to the local VC network, facilitating the appointment of VC directors to their board. However, the presence of VC directors is not limited to firms that were VC-backed at the IPO – 26.9% of nonVC-backed IPO firms also have VC directors as mature firms. These patterns are relevant for a number of reasons. First, they suggest that original VCs from the pre-IPO stage can still be present in firms after a long period of time after the firm has gone public. Second, VCs' involvement in mature public firms is not necessarily an outcome of these firms being VC-backed at the IPO. Our data shows that it is possible for a nonVC-backed IPO firm to have VC directors later as a mature firm. It is also possible for a mature firm to gain VC directors who are different from the original VCs.

We calculate the market value of the firm as the book value of assets less the book value of equity plus the equity market capitalization. The average market value of firms with VC directors is $13.3 billion compared with $10.4 billion for firms without VC directors, with the difference being statistically significant at the 1% level. Though they are younger, firms with VC directors are larger than firms

without VC directors. Firms with VC directors also have a higher Tobin's Q of 2.47, on average, compared to firms with no VC directors which have an average Tobin's Q of 2.01.

Panel B of Table 1 reports descriptive statistics for board characteristics. Firms with VC directors and those without VC directors have similar board size with a mean and median board size of nine. Firms with VC directors have a greater proportion of independent directors on their board. Panel C of Table 1 shows that VC directors serve on a greater number of boards than other type of directors, consistent with the intuition that their supply is scarce in the economy and/or their expertise is highly sought after by mature companies. Finally, VC directors have lower equity ownership in the firm and are younger than non-VC directors.

We investigate whether the board membership by VC directors arises because of an equity ownership stake held by VC investors in the mature firms. For example, VC investors may be blockholders in some mature firms as a remnant of the pre-IPO holdings or as a result of an acquisition of a portfolio company by a mature firm. Using the ownership data of Dlugosz, Fahlenbrach, Gompers and Metrick (2006), we examine the frequency with which the VC director is a direct or indirect 5% blockholder in the firm. We find that in only 5.25% of the mature firms with VC directors, VC directors appear as blockholders. Thus, board membership by VCs is not simply a reflection of their status as large blockholders in mature firms.

3. VC directors, R&D and innovation

3.1. Univariate analysis

Existing research shows that VCs help foster innovation in private VC-backed firms. Hellmann and Puri (2000) present evidence that venture capital involvement helps speed the time to bring an innovation to market for start-up companies. Kortum and Lerner (2000) find that VC-backed firms are

more likely to innovate and to obtain patents than non VC-backed firms. We explore whether VCs play a similar role in promoting innovation in mature firms by analyzing R&D expenditures and patenting activity.

Table 2 shows that firms with VC directors have higher outlays on R&D expenditures. We define R&D intensity as the ratio of R&D expenditures to the market value of the firm. R&D intensity averages 2.41% for firms with VC directors and 1.35% for firms without VC directors, the difference being statistically significant at the 1% level.

Although R&D expenditure is a commonly used metric for how innovative a firm is, patenting activity has been shown to be a better measure of the innovation output of a firm (Trajtenberg (1990) and Griliches (1990)). Hence, we conduct an analysis of the patents obtained by our sample firms. We use the patent database created by Hall, Jaffe and Trajtenberg (2001) and provided by the National Bureau of Economic Research (NBER). These data comprise detailed information on all U.S. patents granted between January 1963 and December 1999, all citations made to these patents between 1975 and 1999, and a broad match of these patents to Compustat firms.[8] Updates of the patents and citations data through 2006 and the match of all the patent assignees to Compustat firms are obtained from NBER Patent Data Project (PDP). The updated patent database makes it possible for us to analyze the innovation output of our sample of firms in terms of the patents they produce and citations they receive for the whole sample period from 1998 to 2006.

NBER records a patent only after it is granted, i.e. after it is approved by United States Patent and Trademark Office (USPTO), and this causes the patent data to suffer from a truncation problem. For example, data on most of the patents filed in 2005 or 2006 are missing since the review process by the patent office takes two years on average (Hall, Jaffe and Trajtenberg (2001)), and the corresponding

[8] The original work by Hall, Jaffe and Trajtenberg (2001) covers patent data until the end of year 1999, which is then extended by Bronwyn H. Hall until the end of 2006.

patent data becomes available only after year 2006. This truncation problem is addressed in the PDP and the patent and citation numbers provided by PDP are corrected for truncation using the methodology described by Hall, Jaffe and Trajtenberg (2001).

We analyze the number of patents produced by our sample firms as a measure of their R&D productivity. However, the simple count of patents may not be a sufficient measure for the technological or economic significance of the patents. Trajtenberg (1990) and Hall, Jaffe and Trajtenberg (2005) document that patent citations are a better measure of the value of innovations since they show a patent's influence on future research activities and its economic importance. Therefore, we also compute the total number of citations for our sample firms.

Table 2 reports the summary statistics for the number of patents and citations for our sample firms. Firms with VC directors produce more patents compared to firms without VC directors. Firms with VC directors produce 31 patents per year on average, compared with 20 patents per year for firms without VC directors. The difference in the number of patents obtained is statistically significant at the 1% level. We also find that for the patents produced from 1998 to 2006, firms with VC directors receive 386 citations through the end of 2006 whereas firms without VC directors receive 215 citations, the difference being statistically significant at the 1% level. Overall, these results suggest that firms with VC directors are not only more innovative in terms of their patent counts, but they also have more influential innovations as measured by the number of citations received on these patents.

Our finding that firms with VC directors are more R&D intensive and more innovative than those without VC directors can be due to either a treatment or selection effect. Under a treatment effect, VC directors have a positive impact on the innovativeness of the firm whose board they sit on. Under a selection effect, firms with high R&D and innovation are more likely to recruit VC directors in order to benefit from the innovation specific human capital and skill set of VCs. It is also possible that VCs desire

to serve on boards of R&D intensive and innovative firms since that may provide them with greater visibility, credibility and a potential exit channel for their existing portfolio of start-up companies. In an attempt to identify causality, we conduct an analysis of the change in the R&D intensity and innovation outcomes of firms after they appoint a VC director to the board.

Table 3 presents the change in the average annual R&D intensity over different time periods around VC director appointments. There are a total of 175 firm-years in our sample in which at least one VC director is appointed to the board, and for 139 of these firm-years we are able to obtain the R&D intensity for the periods before and after the VC director appointment year. We define the year of the VC director appointment as year 0, and calculate the R&D intensity of the sample firms for each year from five years before the appointment year to five years after the appointment year by dividing the annual R&D expenditures by the market value of the firm at the beginning of that year. We then calculate the average R&D intensity of the firm over different time horizons in the pre- and post-VC appointment period. Finally, we measure the change in the average annual R&D intensity by calculating the difference of the two averages in the pre- and post-VC arrival periods. For example, change in the R&D intensity over the period (-3,+3) is obtained as the difference between the average R&D intensity of the firm in the three-year period before the appointment of the VC director and the average R&D intensity in the three-year period after the appointment of the VC director.

As Panel A of Table 3 shows, the mean increase in the annual R&D intensity of a firm from 3 years before to 3 years after a VC director appointment is 0.002 and is statistically significant from zero at the 1% level. Similarly, the change in the R&D intensity from 4 years before to 4 years after the appointment of a VC director is 0.003, significant at the 1% level. Finally, the change in R&D intensity from 5 years before to 5 years after the appointment of a VC director is 0.004, significant at the 1% level. Panel B of Table 3 shows the average change in the R&D intensity after a firm gains a VC director

relative to R&D intensity of other firms in the firm's industry where industry classification follows the 48 Fama and French (1997) industry groupings. We calculate industry-adjusted R&D intensity as the difference between the firm's R&D intensity in a given year and the median R&D intensity in its industry in that year. As Panel B shows, we observe a significant increase in the industry-adjusted R&D intensity of a firm around the VC director appointment date. Overall, these results in Table 3 suggest that firms exhibit an increase in R&D intensity after the appointment of a VC director.

One concern with these results is that R&D intensity increases as a result of acquisitions of other R&D intensive firms rather than an increase in the internal R&D expenditures of the firm. If VC directors facilitate acquisitions of R&D intensive VC-backed start-ups by mature firms, such acquisitions may explain why mature firms experience an increase in their R&D intensity after the appointment of a VC director to their board. To examine this possibility, we consider the change in R&D intensity based on whether the firm acquires a VC-backed firm after the arrival of a VC director to its board. We examine the acquisitions by these firms after the appointment of the first VC director to their board. Among the 130 firms, 66 acquire at least one VC-backed firm after the arrival of a VC director, while 64 firms do not acquire any VC-backed firms after the appointment of their VC director. Panel C of Table 3 shows the change in the R&D intensity of the firms which acquire a VC-backed firm after the appointment of a VC director, while Panel D shows the same statistic for firms which do not acquire a VC-backed firm after the appointment of a VC director. Firms acquiring a VC-backed firm, shown in Panel C, experience an increase in their R&D intensity from 4 years before to 4 years after and 5 years before to 5 years after the appointment of a VC director, significant at the 1% level. Firms which do not acquire any VC-backed firms, on the other hand, experience a significant increase in their R&D intensity in all time periods we examine. Although over the periods (-4,+4) and (-5,+5) firms acquiring VC-backed firms experience a larger increase in their R&D intensity compared to firms acquiring no VC-backed firms, the magnitude of the increase in the R&D intensity is very similar for both groups of firms. Thus, while acquisitions of VC-

backed firm may explain part of the increase in R&D intensity, the increase is not exclusively driven by acquisitions of VC-backed targets.

Our results so far do not necessarily imply that VC directors *cause* the increase in the R&D intensity of the firm whose board they join. It is plausible that firms planning to increase their R&D intensity find it valuable to appoint VC directors to their boards prior to embarking on a path of greater R&D. However, such an interpretation is nonetheless consistent with a value adding role for VCs in areas related to R&D and innovation at mature firms. This is because mature firms embarking on an R&D and innovation intensive strategy would only be willing to appoint VC directors if they see a clear benefit from the innovation specific capital and expertise provided by VC directors. Therefore, while these results do not prove causality, they are consistent with a value-enhancing role for VC directors related to innovation at mature firms.

3.2. Multivariate analysis

We test whether the relation between VC directors and R&D intensity holds in a multivariate framework controlling for other determinants of R&D in panel data regressions in Table 4. The dependent variable in these models is the R&D intensity of a firm, using the presence of VC directors on the board and other firm characteristics as independent variables. *Presence of VC directors* is an indicator variable taking the value of one if the firm has at least one VC on its board and zero otherwise. These regressions control for state-level factors, including state per capita income, state educational attainment and state R&D per capita to account for the possibility that R&D intensive firms and VC firms cluster in the same geographical areas.

Model (1) presents regression estimates with industry and year fixed effects.[9] The coefficient on the presence of VC directors is positive and significant at the 10% level, indicating that the presence of VC directors is associated with higher R&D intensity. To address the concern that the results may be driven by whether or not a firm was VC-backed at its IPO, the model contains an indicator variable, *VC backed at time of IPO*, that equals one for firms that were VC-backed IPO firms.[10] This variable is significant at 1% level. We also include a variable called *VC density*, defined as the ratio of the number of VC firms in a given state to the number of public firms headquartered in that state, to control for the possibility that R&D intensive firms are more likely to locate in areas with greater VC human capital and at the same time are more likely to have VCs as directors on their board due to a greater supply of VCs in the local director pool.[11] This variable, however, is not significantly related to the R&D intensity of the firm. Among the control variables, we find that R&D intensity is positively related to per capita R&D in the state, and negatively related to firm size, firm leverage and return on assets.

To understand whether the effect of VC directors is distinct from that of VC backing, Model (2) considers a restricted sample of firms that were VC-backed at their IPO. In order to see whether the positive relation between VC directors and R&D intensity is primarily driven by the original VC directors who remain on the board following the IPO, we include an indicator variable *IPO-VCs on board * Presence of VC directors* which takes the value of one if the VC director on board has been on the board since the IPO of the firm, and zero if the VC director is a new director who joined the firm after its IPO.

[9] Year-fixed effects in our estimation control for the possibility that our results might be driven by the idiosyncrasies of the internet boom period. In our time-series analysis discussed later, we ensure that our results are not specific to the internet boom period by including indicator variables for the internet boom period from 1999-2001.

[10] Since this variable is missing for firms that went public prior to 1970, we also estimate the model without this variable in untabulated tests and continue to find a positive relation between the presence of VC directors and R&D intensity that is significant at the 10% level.

[11] This variable is relevant in the context of recent work showing that geography impacts corporate finance outcomes. It affects ownership structure of firms (Coval and Moskowitz (1999)), access to financing (Becker (2007)), market valuations (Hong, Kubik and Stein (2008)), shareholder composition (Ivkovich and Weisbenner (2005)) and dividend policy (Becker, Ivkovich and Weisbenner (2010)). In other related work, Chen, Gompers, Kovner and Lerner (2009) study the geographical concentration of VC firms and VC-financed firms and find that VC firms that are located in concentrated areas of VC activity tend to perform better.

We continue to find that the presence of VC directors is positively related to R&D intensity. Thus, even within the sample of VC-backed firms, the presence of VC directors has an incremental effect on R&D. Based on Model (2), the presence of a VC director is associated with R&D intensity that is higher by 0.72%. This effect is economically large given that the average R&D intensity in this subsample of VC-backed firms is 3.59%. In addition, we find that the coefficient on the interaction term representing the presence of the original IPO VCs is not significant. Hence, we find no evidence that the original IPO VCs play a different role than VCs who join the board at a later stage.

We also estimate a model for the subsample of firms which were not VC-backed at the time of their IPO, which are presumably less R&D and innovation intensive than VC-backed IPO firms. Model (3) in Table 4 shows that the coefficient on the presence of VC directors is positive and significant at the 10% level. This result indicates that the presence of VC directors is associated with a higher R&D intensity in nonVC-backed firms as well.

Why are VC directors associated with greater R&D intensity? One explanation is that their innovation specific expertise allows boards to better evaluate the merits of increasing research efforts and set the appropriate strategic priorities for these efforts. If so, we might expect more successful and reputable VCs to be associated with larger increases in firm R&D intensity. To test this proposition, we construct a measure of VC firm reputation based on the market capitalization of IPOs backed by the VC firm in the IPO market (Nahata (2008)). For each VC firm, *VC firm reputation* is calculated by cumulating the dollar market value of all companies taken public by the VC firm until a given calendar year and normalizing it by the aggregate market value of all VC-backed companies that went public until the same calendar year. In Model (4a), which uses our full sample, we find that the interaction term *Presence of VC directors*VC firm reputation* is not statistically significant. However, when we consider the subsamples of firms that were VC-backed at the IPO and those that were not VC-backed in models

(4b) and (4c) respectively, we find that this interaction is positive and statistically significant for the subsample of non VC-backed firms. This suggests that VC directors originating from more successful and reputable VC firms are more positively related to the R&D intensity at firms that were nonVC-backed at their IPO.[12]

To understand whether the positive relation between the presence of VC directors and R&D intensity obtains as a result of a treatment or a selection mechanism, we exploit the time series variation in the board composition of our sample firms. We focus on two different subsamples of firms. The first subsample involves firms which experience the arrival of a VC director to their board and the second subsample involves firms which experience the departure of a VC director from their board during our sample period. In Model (5a) in Table 4, we define an indicator variable, *Post-VC director appointment*, which takes the value of one if a firm-year observation occurs after the firm appoints a VC director, and is zero if it is before the VC director appointment.[13] We also include an interaction of this variable with VC density, *Post-VC director appointment*VC density*. To account for the possibility that both VC director appointments and the subsequent R&D outlays may be driven by acquisitions of VC-backed firms, we include a control variable, *Volume of VC-backed acquisitions*, defined as the total volume of acquisitions of VC-backed firms in a year given as a percentage of firm market value.

Model (5a) shows that the coefficient on *Post-VC director appointment* is positive and significant at the 5% level, implying that firms exhibit higher R&D intensity after the appointment of a VC director

[12] In untabulated tests, we considered other attributes of VCs that may contribute to higher R&D efforts. Specifically, we used the Industry Concentration Index (ICI) to measure the industry concentration of a VC firm's portfolio following Kacperczyk, Sialm, and Zheng (2005) and Tian (2011). We also considered whether the VC firms specialized in early or late stage investments and whether there was an overlap between the VC firm's investment portfolio and the industry of the mature firm. We do not find evidence that these VC firm characteristics are associated with greater R&D expenses.

[13] The *Post-VC director appointment* indicator variable is defined only for those firms that had no VC directors at the beginning of the sample period and subsequently appoint a VC director to their board within the sample period. Hence, this indicator variable is defined only for firms which make the transition from being a firm without a VC director to a firm with a VC director.

to their board. The point estimate implies that R&D increases by 1.85% of firm market value following the appointment of a VC director, a large effect considering that R&D averages 2.33% of firm market value for this subsample of firms. Further, the effect of a VC director appointment on R&D intensity is greater for firms located in lower VC density areas, as indicated by the negative coefficient on the interaction variable between the *Post-VC director appointment* and *VC density*. The estimate on the interaction indicates that the effect of a VC director appointment on R&D intensity increases by 1.05% of firm market value for a one standard deviation decrease in *VC density*.

These results suggest that the positive relation between VC directors and R&D intensity arises due to a treatment effect rather than a selection effect. If our results were due to selection in the sense that VC directors are self-selected onto the boards of R&D intensive firms, we would not expect to observe a significant increase in R&D expenditures in the period following the appointment of a VC director. Our finding that VC director appointments have a stronger association with R&D intensity for firms in low VC density areas suggests instead that the expertise of VC directors is more valuable when firms' access to VCs through other channels is more limited and is consistent with a treatment effect. However, we cannot rule out the possibility that firms, particularly those in low VC density areas, appoint VC directors to the board in anticipation of embarking on greater R&D efforts. Even under this interpretation, our results suggest a value-additive role for VC directors at firms pursuing R&D plans since firms would make such appointments only if the expected benefits exceeded the costs.

We also examine whether the departure of VC directors from the board is associated with a change in R&D intensity. To do so, we define an indicator variable, *post-VC director departure*, which takes the value of one if a firm-year observation in our sample occurs in the period after the firm experiences the departure of a VC director, and zero if the firm-year observation occurs in the period

before the VC director departure. Model (5b) in Table 4 shows that while the coefficient on the *post-VC director departure* is negative, it is not statistically significant.

To further examine whether the relation between the presence of VC directors and R&D intensity arises due to endogenous selection, we adopt the methodology of Altonji, Elder and Taber (2005). Altonji, Elder and Taber (2005) develop an estimation method in the absence of a valid instrument based on the notion that the amount of selection on the observed explanatory variables in a model provides a guide about the amount of selection on the unobservables. This procedure involves estimating a system of two equations, a treatment equation and an outcome equation, by imposing various values on the correlation between the error terms of the two equations. The underlying assumption in this method is that there are some unobservable factors in the estimated model that affect both the selection into treatment and the outcome variable of interest such that there is a positive selection bias, implying a positive correlation between the error terms of the treatment and outcome equations.

Following Ostromogolsky (2011) which extends the bivariate probit model of Altonji, Elder and Taber (2005) to allow for a continuous outcome variable, we employ a treatment effects approach where we estimate a probit model for the presence of VC directors simultaneously with a model for the outcome variable of interest given by the R&D intensity of the firm. We estimate the model using the maximum likelihood method with the error terms clustered at the firm level. The treatment effects approach estimates the coefficients of the explanatory variables in the model equations and tests whether the correlation between the error terms of the treatment equation and the outcome equation, denoted by rho, is significantly different from zero. Applying this method to our main model of R&D intensity, i.e. to Model (1) of Table 4, without imposing any restriction on rho, we obtain an estimate of rho which is close to zero (-0.04). Consistent with this result, the Wald test of independent equations, which tests whether rho is equal to zero, fails to reject the null hypothesis of independent equations with a p-value of 0.71. Thus, we cannot reject the hypothesis of no selection bias in our sample using the Altonji, Elder and Taber

(2005) framework. This implies that unobservables related to R&D intensity and those related to the presence of VC directors are not strongly correlated, mitigating the concern that selection effects are driving our results.

We proceed to examine the relation between the presence of VC directors and innovation outcomes, measured by the patenting activity of the firm, in a multivariate framework. Table 5 presents estimates from Tobit models that use the adjusted number of patents generated and the adjusted number of citations obtained from these patents as dependent variables. These measures are adjusted for year and technology class to correct for truncation in the patent data. To account for the truncation bias in the patent data, we implement the adjustments recommended by Hall, Jaffe and Trajtenberg (2001). Specifically, the number of patents is adjusted by dividing the number of patents obtained by a firm by the mean number of patents in the same cohort, to which the patent belongs, where the cohorts are constructed for each year and technology class defined by USPTO.[14] Similar adjustments are made for the number of citations as well.

Table 5 presents the estimates from the Tobit models. Model (1) shows that the number of patents, adjusted for technology class and year, is not significantly related to the presence of VC directors. In Model (2a), we include the *Post-VC director appointment* and the *VC density* variables as well as their interaction. We find that firms exhibit an increase in the number of patents following the appointment of a VC director, with the effect significant at 1% level. In addition, firms located in lower VC density areas experience a higher increase in the number of patents they obtain after the VC director appointment, implied by the negative coefficient of the interaction variable between the *Post-VC director appointment* and the *VC density* variables which is significant at 1% level. Both of these results are more consistent with a treatment effect of VC directors than a selection effect. Under a selection effect, VC directors would be expected to join boards of firms with high levels of patenting activity while the treatment effect

[14] The technology classes defined by USPTO are: computers and communications, drugs and medical, electrical and electronics, chemical, mechanical and others.

suggests that patenting activity would rise following VC director appointments. Our finding that the relation between director appointments and innovation is stronger for firms in low VC density areas suggests that VC directors are more valuable for firms with limited access to VC expertise through other channels. In Model (2b) in Table 5, we observe a negative but statistically insignificant coefficient for the *post-VC director departure* variable in explaining the number of the patents obtained by the firm following the departure of a VC director.

In Model (3), we include the *VC firm reputation* variable and its interaction with the *Presence of VC directors* variable in our analysis. The coefficient on the interaction variable *Presence of VC directors*VC firm reputation* is positive and significant at the 10% level, suggesting that VC directors coming from more reputable VC firms are more positively related to the number of patents obtained by the firm whose board they serve on.

In Model (4) in Table 5, we find that the number of citations is not significantly related to the presence of VC directors. However, Model (5a) shows that firms obtain more impactful patents measured by the number of citations after the appointment of a VC director to the board. In addition, the relation between VC director appointments and patent citations is stronger for firms located in areas with lower VC density, i.e. firms that stand to benefit more from the innovation expertise of VC directors. Finally, we find in Model (5b) that the number of citations received from patents exhibits a significant decline following the departure of a VC director, as indicated by the negative coefficient on the *post-VC director departure* variable.

In terms of economic magnitudes, the appointment of a VC director to the board is associated with an increase of 8.6 in the adjusted number of patents obtained by the firm in a year and an increase of 7.7 in the adjusted number of citations received by these patents. The departure of a VC director is associated with a reduction of 7.2 in the number of citations received on the patents of the firm. Given

that the mean adjusted number of patents is 2.5, and that of citations is 3.1 for this subsample of firms, these effects are economically large. Another way to illustrate the sizeable relation between VC director appointments and patenting activity is to compare it to the effect of R&D intensity on patents. The point estimates in Model (2a) and (5a) imply that a one standard deviation increase in R&D intensity leads to an increase of 5.6 in the adjusted number of patents and an increase of 6.9 in the adjusted number of citations. Our finding that VC director appointments have a large effect on the patenting activity of mature firms is consistent with Kortum and Lerner (2000) who show that increases in venture capital activity in an industry are associated with significantly higher patenting rates. While Kortum and Lerner (2000) look at VC funding in private firms in an industry, our results point to a complementary finding on the positive effect of VC directors on the innovation output of mature public firms.

Our results on the relation between VC directors and innovation outcomes do not simply reflect the fact that some VC directors acquired their board seats as a result of VC backing at the time of the IPO. In none of the models we analyze, is the coefficient on whether the firm was VC-backed at the time of the IPO statistically significant. Thus, being VC-backed at the time of the IPO does not necessarily imply greater innovation output when the firm becomes mature. This result emphasizes the importance of studying VC involvement in mature firms beyond their IPO stage. Our results suggest that having VC directors on board as a mature firm is a more important determinant of a firm's innovation output than whether it was VC-backed at its IPO. In addition, they suggest that studies examining the effects of VC-backing at the IPO time have limited implications for whether these effects persist when firms become mature in their post-IPO stage. Finally, our finding that VC directors are positively related to the R&D intensity of mature firms which were not VC-backed at their IPO suggests that VCs' role is not limited only to VC-backed firms and they play also an important role for mature firms which did not have VC-backing during their IPO.

4. VC directors and M&A activity

We investigate the role of VC directors in the M&A activity of mature firms. In particular, we examine whether the appointment of a VC director to the board of a firm affects the firm's likelihood of undertaking deals involving VC-backed firms as well as the performance of such deals. We postulate that the presence of VC directors can help expand the investment opportunity set of a mature firm by increasing its access to and information about VC-backed start-ups through the connections and the network of VC directors. Hochberg, Ljunqvist and Yu (2007) show that connections and networks are particularly important in the venture capital industry and VCs exploit their networks to help their portfolio companies succeed. Hence, we examine whether having a VC director is related to the firm's transactions with other VC-backed entrepreneurial start-ups such as the acquisition of VC-backed firms, equity investment in external VC-backed start-ups (also known as corporate venture capital investment), and formation of business relations with VC-backed firms through joint ventures (JVs) and strategic alliances. We also examine the market reaction to announcements of acquisitions, JVs, and strategic alliances to understand whether VC directors are associated with deals that offer greater value creation potential.

4.1. Univariate analysis

Our data on acquisition activity, JVs, and strategic alliances come from the SDC's Mergers and Acquisitions database and our data on corporate venture capital (CVC) backed investment come from the VentureXpert database. Our sample firms participated in 9,436 acquisitions, 3,306 CVC investment rounds, 1,395 joint ventures and 6,637 strategic alliances between 1998 and 2006.

Panel A of Table 6 shows that firms with VC directors appear to exhibit a slightly lower level of M&A activity. On average, firms with VC directors engage in acquisitions amounting to 7.2% of firm market value, compared to 7.8% for mature firms without VC directors. However, there is a sharp

difference in the type of M&A targets that these two sets of firms pursue. Firms with VC directors are more likely to acquire VC-backed firms. We find that 31.6% of the acquisition volume of firms with VC directors involves a VC-backed target whereas this percentage is only 16.4% for firms without VC directors, the difference being significant at the 1% level.

There is a growing literature on the importance of CVC in promoting the innovation output of mature and established firms (Dushnitsky and Lenox (2005, 2006) and Robinson (2008)). Panel B of Table 6 shows that firms with VC directors engage in much more CVC activity. On average, they invest in 0.48 portfolio companies in a year, compared to 0.30 companies for firms without VC directors, and the size of the CVC investment as a percentage of firm market value is greater for firms with VC directors than for firms without VC directors. In addition, the total amount of the CVC investment fund managed by firms with VC directors averages 3.5% of their firm market value compared to 0.8% for firms without VC directors. These differences are all significant at the 1% level. Thus, firms with VC directors invest in a greater number of VC-backed firms, make a larger investment in each start-up, and exhibit a higher amount of total CVC investment than firms without VC directors. Similarly, Panel C of Table 6 shows that firms with VC directors engage in strategic alliances and JVs more frequently, and the partner firms in these deals are more likely to be VC-backed companies.

These results suggest that VC directors improve a firm's ability to innovate by facilitating CVC investment in VC-backed start-ups through their networks and contacts. An alternative explanation is that VC directors use their board membership at a mature firm to channel funding to the companies in their own portfolio. If this is the case, the higher investment in other VC-backed firms might be reflective of an agency cost of having VC directors on the board rather than the pursuit of an efficient investment strategy by mature firms. To evaluate this, we collect data on all the partner companies in strategic alliances, JVs, and CVC deals as well as the target companies in acquisitions, and examine the identity of the VC firms

involved in these partner or target companies. Strikingly, in only 3.8% of the strategic alliance, JV and CVC deals does the VC director at the mature firm originate from the same VC firm that is also backing the target entity. Similarly, in only 3.3% of the acquisitions of VC-backed firms do the VC directors at the mature firm come from the VC firm backing the target firm in the acquisition. This suggests that the link between VC director presence in mature firms and their investment decisions is not driven by the motive of VC directors to generate exit opportunities for the start-up companies in their own portfolio.

4.2. Multivariate analysis

4.2.1 VC directors and acquisitions of VC-backed firms

We explore the relation between the presence of VC directors and acquisition activity in a multivariate setting. We first examine whether having a VC director on board is related to the likelihood of making acquisitions. In Model (1) in Table 7 we set the dependent variable equal to one if the firm makes an acquisition in a given year and to zero otherwise. The results of the probit model show that the presence of VC directors is not significantly related to the probability of making an acquisition.

In Model (2), we examine whether having VC directors is related to the firm acquiring a VC-backed target firm. We use a probit model where the dependent variable takes the value of one if an acquisition of a VC-backed target occurs in a given firm-year and is zero otherwise. Model (2) shows that the coefficient on VC directors is positive and statistically significant at the 10% level. The predicted effect of VC directors on the likelihood of acquisition of VC-backed firms is economically important. Having a VC director on the board translates into a 2.2% increase in the likelihood of acquiring a VC-backed firm in a given firm-year. Given that the unconditional probability of a mature firm with no VC directors acquiring a VC-backed firm is 9.1% in our sample, this effect is economically meaningful.

We also examine the subsample of firms which were not VC-backed at the time of their IPO. The results in Model (3) show that the positive relation between VC directors and likelihood of conducting deals with VC-backed firms also holds for this subsample of firms that were not VC-backed at their IPO.

In Model (4) in Table 7, we examine whether, conditional on a mature firm making an acquisition, the presence of VC directors is related to the target firm acquired being VC-backed. Whereas the unit of observation is a firm-year in the first three models, in Model (4) we include all acquisitions made by our sample firms and set the dependent variable equal to one if the target firm is VC-backed and to zero otherwise. We find that the presence of VC directors is positively related to the target firm being VC-backed at the 1% level of significance. Further, we find that the impact of VC directors on the probability of acquiring a VC-backed firm is greater for firms located in areas with lower VC density. To the extent that mature firms in low VC density areas have less information about VC-backed firms and are more likely to need the help of VC directors in terms of their access to VC-backed target firms compared to firms in high VC density areas, this result is more consistent with the view that VC directors facilitate the firm's ability to acquire VC-backed firms (i.e., a treatment effect) than VC directors being more attracted to the boards of firms with a high likelihood of acquiring VC-backed firms (i.e., a selection effect).

Our results so far establish a positive association between having a VC director on board and the likelihood of undertaking deals with VC-backed target firms. To further understand whether these results are due to a treatment or a selection mechanism we consider appointments and departures of VC directors in our sample. First, we compare the M&A behavior of a firm following the appointment of a VC director to that preceding the appointment. Model (1) of Table 8 shows that the probability of a firm making at least one acquisition does not increase following the appointment of a VC director. Similarly, Model (2) shows that the probability of acquiring a VC-backed firm does not change significantly for firms

following a VC director appointment. However, Model (2) shows that firms located in areas with a lower VC density experience a significant increase in the probability of acquiring a VC-backed firm after a VC director joins the board. The coefficient on the interaction variable between the *Post-VC director appointment* and the *VC density* variables is negative and significant at the 5% level. Model (3) considers the probability that the target firm is VC-backed and Model (4) considers the number of VC-backed target acquisitions that are made. These specifications show that both the probability of acquiring a VC-backed target as well as the number of acquisitions of VC-backed targets are significantly higher following the appointment of a VC director. Further, this relation is stronger for firms located in lower VC density areas, i.e. for firms which stand to benefit more from VCs' ability to facilitate deals with VC-backed start-ups. We examine the effect of departure of a VC director in Model (5), and find a significant reduction in the number of acquisitions of VC-backed firms following the departure of a VC director from the board.

In Model (6), we analyze the role of VC directors on M&A activity for firms that were not VC-backed at the time of their IPO. We find that such firms exhibit a significant increase in the number of acquisitions of VC-backed firms subsequent to the appointment of a VC director to their board, confirming our earlier observation that the role of VC directors is not limited to firms which were VC-backed at their IPO.

Our results suggest that VC directors help facilitate acquisitions between mature firms and VC-backed firms. An alternative explanation, however, is that firms planning acquisitions of VC-backed firms appoint VC directors to the board in anticipation of such acquisitions. Irrespective of the causality underlying this relationship, our results suggest a valuable role for the expertise provided by VC directors related to the acquisition of VC-backed firms. Even if the appointments occur in anticipation of VC-backed acquisitions, firms would only appoint VC directors if they expect to derive a benefit from their presence on the board during such acquisition activity.

4.2.2 VC directors and strategic investments in VC-backed firms

In addition to facilitating the acquisition of VC-backed firms, VC directors can play a broader role in establishing strategic relations with VC-backed firms or by facilitating equity investments in VC-backed firms as a result of having greater access to and information about VC-backed firms in the economy. Consistent with this view, Lindsey (2008) shows firms sharing a common VC investor are more likely to form strategic alliances with each other.

We investigate whether the presence of VC directors on the board is related to the firms' joint venture and strategic alliance activity involving VC-backed firms. We first consider the incidence of JV and strategic alliance activity. Model (1) in Table 9 presents estimates from a probit model where the dependent variable takes the value of one if a mature firm establishes at least one JV or strategic alliance with a VC-backed firm in a given year and is zero otherwise. The coefficient of the VC presence variable is positive and statistically significant at the 1% level, implying that firms with VC directors are more likely to partner with VC-backed firms. Economically, having a VC director on the board is associated with a 2.8% increase in the likelihood of the mature firm establishing JVs or strategic alliances with at least one VC-backed firm. Given that the unconditional probability of a mature firm with no VC directors establishing JVs or strategic alliances with a VC-backed firm is 5.8% in our sample, this effect is economically large.

Next, we examine the frequency of JVs and strategic alliances. Model (2) in Table 9 presents regression estimates where the dependent variable is the total number of JVs and strategic alliances with VC-backed firms for each firm and each year. The models include the usual control variables along with industry and year fixed effects. The coefficient on the presence of VC directors is positive and statistically significant at the 5% level. The estimates imply that having a VC director on the board corresponds to a

4% increase in the number of JVs and strategic alliances with VC-backed firms. This result suggests that firms with VC directors engage in a greater number of JVs and strategic alliances with VC-backed firms.

Finally, we examine whether the presence of VC directors is related to the likelihood of CVC investments in VC-backed start-ups. Model (3) in Table 9 presents probit estimates for the likelihood of a public firm undertaking a CVC investment where the dependent variable takes the value of one if the public firm invests in a VC-backed start-up and zero otherwise. The coefficient on the presence of VC directors is positive and statistically significant at the 5% level, indicating that the presence of VC directors is positively related to the likelihood of the mature firm undertaking CVC investments in start-ups. The magnitude of this effect is sizeable – having a VC director on the board is associated with a 1.5% increase in the likelihood of a mature firm undertaking an equity investment in a start-up company. Given that the unconditional probability of a mature firm with no VC directors undertaking a CVC investment is 1.1% in our sample, this effect is economically large. In addition, the estimates in Model (4) show that the presence of VC directors on board has a positive and significant effect, at the 1% level, on the total amount of CVC investment in VC-backed firms as well.

In an attempt to distinguish between treatment and selection effects, we proceed with a time series analysis where we look at the change in the amount of a firm's strategic investments in VC-backed firms subsequent to the arrival and departure of VC directors. Model (1a) in Table 10 shows that the coefficient on *Post-VC director appointment* is positive but not statistically significant. However, the coefficient on the interaction between *Post-VC director appointment* and *VC density* is negative and significant at the 5% level. This implies that firms located in low VC density areas exhibit an increase in the likelihood of partnering other VC-backed firms in strategic alliances and joint ventures following the appointment of a VC director. Similarly, in Model (1b), we find a significant decrease in the likelihood of

partnering with a VC-backed firm after a VC director departs the board, and this effect is more pronounced for firms in low VC density areas.

Consistent with Model (1a), Model (2a) shows that firms in areas of low VC density exhibit a greater number of joint ventures and strategic alliances with other VC-backed firms in periods following the appointment of a VC director, and Model (2b) suggests that there is a reduction in the number of strategic relations with VC-backed firms subsequent to the departure of a VC director. Finally, Model (3) provides evidence that firms are more likely to undertake a CVC investment in the post-VC director appointment period, regardless of whether they are located in high or low VC density areas.

Overall, these results on JVs, strategic alliances, and CVC investments suggest that the VC directors play a significant role in expanding the investment opportunity set of the mature firms, particularly those in low VC density areas, by facilitating strategic relationships between these firms and entrepreneurial VC-backed firms.

4.2.3 VC directors and M&A announcement returns

For more direct evidence on whether the appointment of VC directors helps create value for mature firms, we study the market reaction to announcements of acquisitions in our sample. For each acquisition, we calculate the acquirer's cumulative abnormal returns (CARs) over the announcement window (-1,+1) following Brown and Warner (1985). We use the CRSP value-weighted return as the market return and estimate the market model parameters over the interval from 210 to 30 days prior to the announcement date.

As the first row in Table 11 shows, the abnormal returns for all the acquisition announcements in our sample are similar in the periods before and after the appointment of a VC director. However, separating the sample into acquisitions of VC-backed firms and acquisitions of nonVC-backed firms

indicates that VC director appointments are associated with higher abnormal returns for VC-backed acquisitions. Prior to the appointment of a VC director, the mean CAR for acquisitions of VC-backed firms is -1.52% but is 0.09% following the appointment of a VC director. This difference is statistically significant at the 5% level. A similar change in CARs is not observed for acquisitions involving nonVC-backed target firms. This result is consistent with the interpretation that the appointment of a VC director allows the firm to undertake deals with VC-backed targets that offer greater value creation potential due to the VC's expertise in understanding and evaluating entrepreneurial and start-up firms. For joint ventures and strategic alliances, although the CARs are higher following the appointment of a VC director, the difference is not statistically significant.

We conduct a multivariate analysis in Table 12 where the dependent variable is the acquirer's CAR over the (-1,+1) window around the acquisition announcement day. In Model (1) in Table 12, the independent variable of interest is *Presence of VC directors*, which takes the value of one if the acquirer has VC directors at the time of the M&A announcement and zero otherwise. The regressions control for whether the target firm is VC-backed, the method of payment, whether the target is private, whether the deal is diversifying, acquirer size, acquirer leverage, acquirer return on assets, the relative size of the deal, whether the deal is hostile and whether it involves a tender offer. Model (1) shows that the presence of VC directors on board is not related to acquirer cumulative abnormal returns around the announcement date. We also find that announcement returns are significantly lower when the target firm is VC-backed. Consistent with the results in existing work in M&A literature, we find that stock financed deals and diversifying deals are associated with lower abnormal announcement returns. Similarly, deals by large acquirers and deals with greater transaction size relative to acquirer size also generate lower announcement returns.

In Model (2), we use the indicator variable, *M&A after VC appointment*, which takes the value of one if the M&A deal takes place after the appointment of the VC director and zero otherwise. We also use an interaction variable, defined as the interaction of *M&A after VC appointment* and *VC-backed target firm*. The coefficient on the interaction variable is positive and significant at the 5% level, suggesting that firms obtain significantly higher CARs in deals involving a VC-backed target firm following the appointment of a VC director. This result is consistent with the interpretation that VC directors' knowledge and information advantage regarding VC-backed targets plays a positive role in implementing M&A deals with greater value creation. The appointment of a VC director is associated with 3.7% higher acquirer CAR for acquisitions involving VC-backed targets, an economically meaningful effect considering that the average acquirer CAR in our sample is -0.3%.

Overall, these results suggest that the appointment of VC directors is followed by a greater volume of deal flow with VC-backed firms and that the acquisitions of VC-backed targets are also associated with greater value creation. These results indicate a value creating role for VC directors through their impact on a firm's acquisition strategy and are supportive of a treatment effect where VC directors lead to an improvement in the deal-making ability of mature firms with respect to acquisitions of entrepreneurial targets. The results are harder to explain as a selection mechanism since information on potential acquisitions would not be known to prospective VC directors and hence is unlikely to influence their decision to join the board of a mature firm.

5. VC directors and operating performance

We explore whether the appointment of VC directors to the board is associated with changes in the firm's operating performance. In Models (1) and (2) in Table 13, the dependent variable is the ROA (return on assets) of a firm, defined as the ratio of operating income before depreciation to total assets,

and the main independent variable of interest is *Post-VC director appointment*. As before, we use *VC density*, its interaction with the *Post-VC director appointment* variable as well as other firm state level variables. We find that firms experience a significant improvement in their operating performance after the arrival of a VC director to their board, as indicated by the positive coefficient on the *Post-VC director appointment* variable in Model (1). In addition, the improvement in the operating performance is greater for firms located in low VC density areas. In Model (2), we examine the change in ROA subsequent to the departure of a VC director from the board, but find no significant change in ROA. In Models (3) and (4) in Table 13, we use ROS (return on sales) as an alternative measure of operating performance. We continue to observe the positive change in the operating performance of the firm subsequent to the arrival of a VC director to the board in Model (3) and no change in ROS following VC director departures in Model (4). The appointment of a VC director to the board leads to a 5.7% (7.0%) increase in ROA (ROS). Given that the mean ROA (ROS) is 14.4% (13.6%) in our sample, this effect is economically sizeable. These results suggest that the facilitation of innovation outcomes and M&A strategy by VC directors of mature firms is associated with improved operating performance for these firms.

6. Announcements of VC director appointments to boards

We study announcement effects associated with appointments of VC directors to the board. If the presence of VC directors and the innovation activities of mature firms are linked through an unobserved factor or through a selection mechanism, we would not expect that the appointment of a VC director should be associated with meaningful information effects. On the other hand, if the appointment signals that the firm is more likely to embark on innovation activity and the specific expertise of the VC director improves the firm's ability to pursue such activities, we expect to observe a positive announcement return if these activities are considered to be value-enhancing.

We hand collect announcement dates for all VC and non-VC director appointments in our sample by searching the LexisNexis data retrieval system for public news and company press releases. We obtain announcement dates for 422 director appointments to boards of mature firms, of which 109 correspond to appointments of VC directors. We follow the standard event study methodology of Brown and Warner (1985) to measure the announcement abnormal returns. We use the CRSP value-weighted return as the market return and estimate the market model parameters over the interval from 210 to 30 days prior to the announcement date.

The mean abnormal return on the announcement day for the 109 appointments of VC directors over days (-1,0) is 0.38% and is significant at the 5% level. In 33 cases, firms announce the appointment of a VC director concurrently with that of a non-VC director. For the sample of 76 VC director appointments that exclude observations where a non-VC director is appointed concurrently, we observe a mean abnormal return over days (-1,0) of 0.38%, significant at the 5% level. For the 313 non-VC director appointments in our sample, we find a mean abnormal return over days (-1,0) of 0.12% which is not significantly different from zero.

The positive and significant abnormal returns around appointments of VC directors that we find are in sharp contrast to much of the extant evidence on the wealth effects of outside director appointments. For comparison, Rosenstein and Wyatt (1990), Shivdasani and Yermack (1999), and Fich (2005) all document statistically insignificant excess returns around outside director appointments. Perry and Peyer (2005) find negative excess returns around director appointments in their sample, and Masulis, Wang, and Xie (2010) document significantly negative excess returns around appointments of foreign outside directors.

Table 14 reports regression estimates of the announcement abnormal returns over days (-1,0) where observations involving multiple director appointments on the same day are excluded. Our primary

independent variable of interest is an indicator variable, *Appointment of a VC director*, which takes the value of one if the appointed director is a VC, and is zero otherwise. We also include interactions of this variable with *R&D intensity* and *VC density*. The regressions control for governance variables such as *Board size* and *Proportion of VC directors on board*, whether the appointment increases the size of the board, as well as firm specific variables such as *Firm Size, Tobin's Q, Leverage,* and *Return on Assets*.

As Model (1) shows, *Appointment of a VC director* is positive and significant at the 1% level, indicating that VC director appointments are viewed more positively than appointments of non-VC directors. However, the positive relation between VC director appointments and announcement returns is driven by firms with relatively low R&D intensity, suggesting that investors view VC director appointments favorably for less R&D intensive firms. We estimate that a one standard deviation decrease in R&D intensity is associated with a 1% greater abnormal return around over days (-1,0) around VC director appointments. This result is consistent with the view that less R&D intensive firms stand to benefit more from the innovation specific expertise of VC directors. In Model (2), we add *VC density* and its interaction with *Appointment of a VC director*. The coefficient on the interaction is estimated to be positive and significant at the 10% level in this specification.

7. Conclusions

We show that VCs play an important role in mature public firms a long time after their IPO. Our paper complements the findings on the importance of VCs for small and private start-ups by documenting that VCs provide expertise to mature public companies past their IPO stage. Specifically, we find that VCs directors have a positive effect on innovation outcomes and investment policies at mature public firms. These firms experience a significant increase in their R&D intensity and innovation outcomes subsequent to the appointment of a VC director to their board. In addition, the arrival of a VC director to the board of a firm increases the amount of the M&A activity involving VC-backed targets that the firm

undertakes. Acquisitions of VC-backed targets that mature firms conduct following the appointment of a VC director also generate higher announcement returns, suggesting that VCs appear to improve a firm's ability to undertake value-enhancing M&A deals with VC-backed firms. We find that the positive role of VC directors on R&D, innovation outcomes, and M&A activity are more pronounced for firms located in areas of lower VC density. Thus, VC directors appear to be more valuable for firms that have less access to VC expertise through local networks due to their geographic locations.

Event study analysis of new director appointments shows that the market perceives VC director appointments to the board as value enhancing, as evidenced by the positive abnormal returns associated with such announcements. These announcement effects are larger for firms with lower R&D intensity. These results illustrate a specific channel through which board composition affects corporate policies through the expertise of directors and illustrate that boards play a broader role than their monitoring function.

An interesting question is why VC professionals have incentives to sit on the boards of mature public companies since this is likely to be costly in terms of their time and may potentially detract from their primary responsibilities at their VC firm. One possibility is that VCs derive personal benefits related to their board appointment. Although we find that deals between mature firms and VC-backed firms rarely involve the VC firm from where the VC director originates, it is possible that the increased deal activity involving VC-backed firms enhances the network and reputation of the VC directors. It is also possible that serving on the board of a large public company provides visibility to VC directors that is beneficial in their primary jobs of fundraising and investing activities as VCs. Further, it is possible that detailed knowledge of R&D efforts at large public companies may be valuable in assessing the investment potential of emerging technologies that VCs invest in. The interplay between VCs role as

directors of mature public companies and their role as capital providers for start-up entities appears to be a fruitful area for further research.

Overall, our paper suggests that, in addition to their role as providers of finance and advice for small and private firms, VCs play a significant role in enhancing R&D and innovation at mature public firms, even long after their IPO stage. Thus, the effect of VCs in promoting innovation appears to be much broader than is commonly thought.

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Table 1
Summary Statistics

This table presents the descriptive statistics of firm, board, and director characteristics for IRRC firms between 1998 and 2006. Panel A presents the descriptive firm statistics of our sample of IRRC firms. Firm age is defined as the number of years since the firm's foundation. "VC-backed at the time of IPO" is an indicator variable which takes the value of one if the firm is VC-backed at the time of the IPO and zero otherwise. The market value of assets (MVA) is defined as the book value of assets less the book value of equity plus the equity market capitalization. Total assets equal the book value of assets. Tobin's Q is the ratio of market value of assets to book value of assets. Leverage is the ratio of interest bearing debt to operating assets. Panel B and Panel C present the descriptive board statistics and the descriptive director statistics, respectively. VC directors are directors serving on public firms' boards who have worked as venture capitalists in venture capital firms. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

Panel A: Firm Statistics

	Overall Sample			Firms with at least one VC director on board			Firms with no VC director on board			Comparison between VC- and nonVC-board firms	
	N	Mean	Median	N	Mean	Median	N	Mean	Median	t-statistics	z-statistics
Firm age	3,971	31.33	23	1,566	25.38	19	2,405	35.21	26	-13.62***	-16.28***
Years since IPO	9,249	22.81	17	2,840	19.41	13	6,409	24.32	19	-12.27***	-15.28***
VC-backed at the time of the IPO (indicator)	4,608	0.45	0	1,768	0.65	1	2,840	0.32	0	23.26***	22.01***
Market value of assets (MVA) ($ millions)	8,417	11,288.49	2,190.31	2,565	13,301.05	2,791.25	5,852	10,406.36	1,978.51	3.08***	9.06***
Total assets ($ millions)	8,434	5,663.29	1,225.80	2,569	5,539.31	1,410.30	5,865	5,717.59	1,151.15	-0.36	4.37***
Tobin's Q	8,417	2.15	1.66	2,565	2.47	1.88	5,852	2.01	1.59	10.97***	13.34***
Leverage	8,412	0.30	0.30	2,562	0.29	0.26	5,850	0.31	0.32	-1.18	-6.79***

Table 1 (continued)

Panel B: Board Statistics

	Overall sample			Firms with at least one VC director on board			Firms with no VC director on board			Comparison between VC- and nonVC-board firms	
	N	Mean	Median	N	Mean	Median	N	Mean	Median	t-statistics	z-statistics
Board size	9,249	8.91	9	2,840	8.87	9	6,409	8.93	9	-1.12	-1.51
Number of VC directors	9,249	0.42	0	2,840	1.36	1	6,409	0.00	0		
Percentage of VC directors	9,249	5.06	0	2,840	16.48	14.29	6,409	0.00	0		
Percentage of independent directors	9,249	65.61	66.67	2,840	67.67	70.00	6,409	64.70	66.67	8.00***	7.53***

Panel C: Director Statistics

	Overall sample			VC directors			Non-VC directors			Comparison between VC and non-VC directors	
	N	Mean	Median	N	Mean	Median	N	Mean	Median	t-statistics	z-statistics
Number of other board seats held	82,342	0.88	0	3,872	1.24	1	78,470	0.86	0	16.49***	20.19***
Percentage of shares held by a director	82,297	1.15	0.06	3,864	0.62	0.08	78,433	1.18	0.06	-10.44***	2.29**
Director age	82,365	59.05	59	3,875	56.82	57	78,490	59.16	59	-16.52***	-15.49***

Table 2
VC Directors and Firm Innovation

This table presents the descriptive statistics for the innovative activity of the firms in our sample. We report statistics for R&D expenditures, the number of patents produced and eventually granted, the number of citations received by those patents, and the number of citations excluding self-cites. The patent and citation numbers are corrected for truncation and pooled for all firm-years during the sample period from 1998 to 2006. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	Overall sample			Firms with at least one VC director on board			Firms with no VC director on board			Comparison between VC- and nonVC-board firms	
	N	Mean	Median	N	Mean	Median	N	Mean	Median	t-statistics	z-statistics
R&D expense ($ millions)	8,423	143.18	5.45	2,568	190.97	23.61	5,855	122.21	0.55	4.59***	16.33***
R&D expense (as a percentage of mva)	8,410	1.68	0.32	2,565	2.41	1.15	5,845	1.35	0.03	13.12***	15.75***
R&D expense (as a percentage of total assets)	8,423	3.42	0.58	2,568	5.28	2.44	5,855	2.60	0.04	17.47***	18.00***
R&D expense (as a percentage of sales)	8,422	6.28	0.54	2,567	9.88	2.44	5,855	4.70	0.04	7.01***	18.69***
Number of patents	8,683	23.56	0	2,645	30.87	0	6,038	20.35	0	2.68***	8.81***
Number of citations	8,683	267.25	0	2,645	385.65	0	6,038	215.38	0	2.71***	8.20***
Number of citations excluding self-cites	8,683	199.01	0	2,645	309.36	0	6,038	150.67	0	3.13***	8.09***

Table 3
Change in R&D Intensity Around VC Director Appointments

This table presents the change in the average annual R&D intensity of firms over different time periods around the VC director appointment. We define the year of the VC director appointment as year 0, and calculate the R&D intensity of the sample firms for each year from year -5 to year +5 by dividing the annual R&D expenditures by the market value of the firm at the beginning of that year. We then calculate the average R&D intensity of the firm over different time horizons in the pre- and post-VC appointment period. We find the change in the average annual R&D intensity by calculating the difference of the two averages in the pre- and post-VC arrival periods. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	N	Mean	Median	t-statistic	p-value for signed rank test
Panel A: Change in Average R&D Intensity					
Change over (-3,+3)	139	0.002	0	2.62***	0.0025
Change over (-4,+4)	139	0.003	0	3.91***	<.0001
Change over (-5,+5)	139	0.004	0	3.57***	0.0002
Panel B: Change in Average Industry-Adjusted R&D Intensity					
Change over (-3,+3)	139	0.002	0	2.25**	0.0037
Change over (-4,+4)	139	0.003	0	3.22***	0.0008
Change over (-5,+5)	139	0.003	0	2.65***	0.0038
Panel C: Change in Average R&D Intensity for Firms That Acquire a VC-Backed Firm After the VC Director Appointment					
Change over (-3,+3)	66	0.002	0	1.44	0.1748
Change over (-4,+4)	66	0.004	0	2.88***	0.0042
Change over (-5,+5)	66	0.005	0	2.70***	0.0061
Panel D: Change in Average R&D Intensity for Firms That Do Not Acquire a VC-Backed Firm After the VC Director Appointment					
Change over (-3,+3)	64	0.003	0	3.25***	0.0011
Change over (-4,+4)	64	0.003	0	3.36***	0.0011
Change over (-5,+5)	64	0.003	0	2.55***	0.0043

Table 4
VC Directors and R&D Intensity

This table shows the estimation results of OLS regressions for R&D intensity of our sample of firms. Models (1) and (4a) use the full sample; Models (2) and (4b) are estimated for the subsample of VC-backed firms, and models (3) and (4c) are estimated for the subsample of nonVC-backed firms in our sample. Model (5a) uses the subsample of firms which experience the arrival of a VC director, whereas Model (5b) uses the subsample of firms which experience the departure of a VC director. The dependent variable, *R&D Intensity*, is defined as the R&D expenditure of the firm as a percentage of its market value of assets. *Presence of VC directors* is an indicator variable taking the value of one if the firm has at least one VC on its board and zero otherwise. *VC-backed at the time of IPO* is an indicator variable taking the value of one if the firm is VC-backed and zero otherwise. *VC density* is defined as the ratio of the number of VC firms in a given state to the number of public firms headquartered in that state. *IPO-VCs on board* is an indicator variable taking the value of one if there are VCs on board that are from the IPO stage and zero otherwise. *VC firm reputation* is calculated by cumulating the dollar market value of all companies taken public by the VC firm until a given calendar year and normalizing it by the aggregate market value of all VC-backed companies that went public until the same calendar year. *Post-VC director appointment* is an indicator variable taking the value of one if a firm-year observation occurs in the period after the firm obtains a VC director and zero if the firm-year observation occurs in the period before the VC director appointment. *Post-VC director departure* is an indicator variable taking the value of one if a firm-year observation occurs in the period after the VC director leaves the board and zero if the firm-year observation occurs in the period before the VC director departure. *Volume of VC-backed acquisitions* is the total volume of VC-backed firm acquisitions undertaken by the firm in a year. *Board size* is the natural logarithm of the number of directors on board, *Firm size* is the natural logarithm of total assets, *Tobin's Q* is the ratio of market value of assets to book value of assets, *Leverage* is defined as interest bearing debt divided by total assets, *Firm public age* is the natural logarithm of the number of years since the firm's IPO, *Return on assets* is defined as the ratio of operating income before depreciation to total assets, *Intangible assets* is defined as total assets minus property, plant and equipment divided by total assets, and *5-year post-IPO return* is the 5-year return of the public firm right after its IPO. *State per capita income* is the per capita income in the state of the firm, *State educational attainment* is defined as the percentage of the population age 25 and over with a bachelor's degree or more, and *State R&D per capita* is the total R&D expense per capita in the state of the firm. The models also include a constant term, year and industry fixed effects which are not reported. Industry dummies are assigned according to the Fama-French 48 industry groups. For each independent variable, the first row reports its estimated coefficient and the second row the corresponding t- or z-statistic. All standard errors are heteroskedasticity-robust and are clustered at the firm level. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	(1)	(2)	(3)	(4a)	(4b)	(4c)	(5a)	(5b)
Presence of VC directors	0.339	0.717	0.334	0.122	-0.594	0.359		
	1.77*	1.89*	1.65*	0.31	-1.11	1.22		
VC-backed at the time of IPO	0.798			0.597			2.161	2.023
	3.96***			1.81*			2.50**	2.69***
VC density	1.726	3.336	0.508	2.576	1.938	2.750	14.03	-0.299
	1.44	1.41	0.42	1.14	0.44	1.43	1.68*	-0.06
IPO-VCs on board * Presence of VC directors		-0.516						
		-1.41						
VC firm reputation				8.116	-5.026	5.173		
				0.88	-0.30	1.14		
Presence of VC directors * VC firm reputation				0.565	8.163	15.16		
				0.05	0.43	2.05**		
Post-VC director appointment							1.848	
							2.49**	
Post-VC director appointment * VC density							-10.95	
							-1.86*	
Post-VC director departure								-1.074
								-1.20
Post-VC director departure * VC density								1.972
								0.43
Volume of VC-backed acquisitions							0.003	-0.030
							0.12	-1.73*
Board size	0.288	0.474	0.238	0.391	0.695	-0.603	-1.228	1.319
	0.84	0.78	0.64	0.57	0.76	-0.95	-0.93	0.98
Firm size	-0.480	-0.893	-0.209	-0.732	-0.876	-0.0857	-0.454	-0.516
	-5.42***	-5.93***	-2.18**	-4.88***	-4.33***	-0.63	-1.14	-1.48
Tobin's Q	-0.003	0.0290	0.0585	0.0506	0.0381	-0.0158	0.258	-0.141
	-0.09	0.79	1.08	0.84	0.88	-0.17	1.61	-1.13
Leverage	-0.822	-1.192	-0.603	-0.362	-2.312	-0.495	1.807	-2.066
	-1.92*	-1.31	-1.82*	-0.40	-1.77*	-1.26	2.37**	-1.24
Firm public age	0.208	1.152	-0.215	0.782	1.089	0.199	1.529	-0.602
	1.17	2.73***	-1.29	2.24**	1.87*	0.69	1.63	-0.84
Return on assets	-9.943	-13.85	-6.409	-14.08	-19.15	-3.046	-13.57	-10.70
	-6.07***	-4.45***	-5.01***	-3.67***	-3.62***	-2.03**	-3.85***	-2.53**
Intangible assets	-0.023	-1.146	0.283	-0.924	-2.833	1.705	2.133	5.366
	-0.05	-0.91	0.67	-0.90	-1.76*	1.87*	1.02	2.17**
5-year post-IPO return	0.003	0.00586	0.00875	-0.0123	-0.0360	0.0159	0.0751	-0.145
	0.15	0.16	0.27	-0.31	-0.76	0.19	0.27	-1.75*
State per capita income	-0.029	-0.0619	-0.0266	-0.0678	-0.194	-0.0260	-0.234	-0.040
	-0.81	-0.80	-0.98	-1.01	-1.88*	-0.60	-1.83*	-0.38
State educational attainment	-1.050	-0.128	-0.313	-2.353	-1.127	-0.481	17.99	0.201
	-0.31	-0.02	-0.10	-0.41	-0.12	-0.12	1.30	0.02
State R&D per capita	0.485	0.246	0.555	0.293	0.550	0.347	-0.410	1.132
	3.07***	0.76	3.70***	0.85	0.94	1.42	-0.61	1.95*
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Adjusted R^2	0.4506	0.4552	0.4084	0.4863	0.5222	0.5118	0.4277	0.4445
Sample size	3700	1595	2086	1207	753	454	206	260

Table 5
VC Directors and Innovation Activity

This table presents estimates from Tobit models, where the dependent variables are the adjusted number of patents and the adjusted number of citations. The adjusted number of patents is obtained by dividing the number of patents for each firm by the mean of the number of patents in the same cohort, to which the patent belongs, where the cohorts are constructed for each year and technology class defined by United States Patent and Trademark Office (USPTO). Similar adjustments are made for the number of citations. Models (1), (3), (4) and (6) use full sample; Models (2a) and (5a) use the subsample of firms which experience the arrival of a VC director, whereas Model (2b) and (5b) use the subsample of firms which experience the departure of a VC director. *Presence of VC directors* is an indicator variable taking the value of one if the firm has at least one VC on its board and zero otherwise. *VC-backed at the time of IPO* is an indicator variable taking the value of one if the firm is VC-backed and zero otherwise. *VC density* is defined as the ratio of the number of VC firms in a given state to the number of public firms headquartered in that state. *VC firm reputation* is calculated by cumulating the dollar market value of all companies taken public by the VC firm until a given calendar year and normalizing it by the aggregate market value of all VC-backed companies that went public until the same calendar year. *Post-VC director appointment* is an indicator variable taking the value of one if a firm-year observation occurs in the period after the firm obtains a VC director and zero if the firm-year observation occurs in the period before the VC director appointment. *Post-VC director departure* is an indicator variable taking the value of one if a firm-year observation occurs in the period after the VC director leaves the board and zero if the firm-year observation occurs in the period before the VC director departure. *R&D intensity* is the R&D outlay of the firm as a proportion of its market value of assets, *Board size* is the natural logarithm of the number of directors on board, *Firm size* is the natural logarithm of total assets, *Tobin's Q* is the ratio of market value of assets to book value of assets, *Leverage* is defined as interest bearing debt divided by total assets, *Firm public age* is the natural logarithm of the number of years since the firm's IPO, *Return on assets* is defined as the ratio of operating income before depreciation to total assets, *Intangible assets* is defined as total assets minus property, plant and equipment divided by total assets, and *5-year post-IPO return* is the 5-year return of the public firm right after its IPO. *State per capita income* is the per capita income in the state of the firm, *State educational attainment* is defined as the percentage of the population age 25 and over with a bachelor's degree or more, and *State R&D per capita* is the total R&D expense per capita in the state of the firm. The models also include a constant term which is not reported. For each independent variable, the first row reports its estimated coefficient and the second row the corresponding z-statistic. All standard errors are heteroskedasticity-robust and are clustered at the firm level. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	Technology Class- and Year-Adjusted Number of Patents				Technology Class- and Year-Adjusted Number of Citations			
	(1)	(2a)	(2b)	(3)	(4)	(5a)	(5b)	(6)
Presence of VC directors	-0.939 -0.99			2.577 1.24	-0.904 -0.59			3.920 1.33
VC-backed at the time of IPO	0.730 0.74	0.0908 0.05	-1.043 -0.89	0.582 0.50	0.906 0.55	-0.475 -0.17	-0.840 -0.35	0.308 0.18
VC density	-1.367 -0.24	75.67 3.52***	2.821 0.41	9.630 1.25	-4.983 -0.49	129.7 3.15***	-1.489 -0.11	17.80 1.61
VC firm reputation				-88.95 -2.29**				-116.2 -2.05**
Presence of VC directors * VC firm reputation				64.30 1.71*				95.92 1.60
Post-VC director appointment		8.634 2.50***				7.695 1.99**		
Post-VC director appointment * VC density		-66.03 -2.98***				-91.77 -3.01***		
Post-VC director departure			-1.684 -1.29				-7.240 -2.38**	
Post-VC director departure * VC density			-2.002 -0.32				9.263 0.73	
R&D intensity	83.46 4.60***	165.2 4.22***	37.74 2.36**	67.07 2.81***	129.2 4.47***	205.4 4.20***	59.79 2.52***	80.85 2.95***
Board size	-2.239 -1.36	-6.561 -1.62	-0.984 -0.41	-2.375 -1.15	-4.555 -1.56	-11.21 -1.82*	-3.183 -0.81	-4.208 -1.35
Firm size	3.316 4.31***	3.922 5.96***	2.544 3.14***	3.159 3.14***	5.373 4.29***	5.833 5.27***	4.239 3.26***	4.166 3.34***
Tobin's Q	0.0620 0.69	0.176 0.71	0.244 0.65	0.0204 0.28	0.218 1.34	0.538 1.93*	0.292 0.58	0.105 0.84
Leverage	-0.578 -0.63	-2.856 -0.68	-0.481 -0.19	-1.332 -0.95	-0.216 -0.14	-8.542 -1.13	-0.297 -0.05	-2.390 -1.03
Firm public age	0.595 0.73	6.623 2.49***	-0.218 -0.19	0.583 0.40	0.988 0.76	12.37 2.72***	0.647 0.36	1.392 0.71
Return on assets	-3.972 -1.37	-5.281 -0.86	-11.15 -2.25**	-1.659 -0.58	-5.962 -1.15	-13.46 -1.40	-16.36 -2.11**	-2.485 -0.59
Intangible assets	2.695 1.24	-3.143 -0.67	6.656 1.47	5.372 1.86*	3.401 0.88	-1.632 -0.22	14.73 1.33	8.109 1.91*
5-year post-IPO return	-0.127 -1.63*	1.803 2.39**	0.010 0.08	-0.097 -0.93	-0.212 -1.70*	3.744 2.93***	-0.058 -0.27	-0.079 -0.57
State per capita income	-1.060 -4.48***	-2.094 -3.18***	-0.246 -1.38	-0.996 -4.89***	-2.270 -4.22***	-3.464 -3.13***	-0.505 -1.57	-1.748 -5.21***
State educational attainment	25.42 2.24**	89.58 2.49***	-6.965 -0.54	39.59 2.62***	57.09 2.76***	145.8 2.44**	-17.26 -0.72	62.64 2.47***
State R&D per capita	4.290 4.11***	0.766 0.28	0.200 0.27	3.725 3.19***	8.461 3.87***	0.00638 0.00	-0.221 -0.17	5.296 3.38***
Pseudo R^2	0.0924	0.2443	0.1639	0.1018	0.0977	0.2785	0.1478	0.1083
Sample Size	3715	206	260	1212	3715	206	260	1212

Table 6
VC Directors, and Acquisitions and Strategic Investments in VC-Backed Firms

This table presents the summary statistics for the acquisition transactions, corporate venture capital (CVC) investments, joint ventures (JVs) and strategic alliances conducted by our sample of firms between 1998 and 2006. Panel A reports the statistics for acquisition volume for firm-years when the firm conducts an acquisition. Panel B shows the number and volume of the CVC investments of the sample firms. Panel C presents the statistics for the number of JVs and strategic alliances formed by the sample firms. The market value of assets (MVA) is defined as the book value of assets less the book value of equity plus the equity market capitalization. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	Overall Sample			Firms with at least one VC director on board			Firms with no VC director on board			Comparison between VC- and nonVC-board firms	
	N	Mean	Median	N	Mean	Median	N	Mean	Median	t-statistics	z-statistics
Panel A: Acquisition Activity											
Acquisition volume as a percentage of acquirer's MVA	2,841	7.53	3.01	1,052	7.15	2.72	1,789	7.76	3.21	-1.25	-2.11**
VC-backed target acquisition volume as a percentage of total acquisition volume	2,841	22.06	0	1,052	31.64	0	1,789	16.43	0	9.61***	10.63***
Panel B: Corporate Venture Capital (CVC) Investments											
Number of portfolio companies in which the firm makes CVC investment	9,249	0.35	0	2,840	0.48	0	6,409	0.30	0	2.27**	11.10***
Total CVC investment (as a percentage of MVA)	8,406	0.66	0	2,564	1.47	0	5,842	0.31	0	5.82***	10.99***
Size of firm's CVC fund (as a percentage of MVA)	8,113	1.56	0	2,391	3.48	0	5,722	0.76	0	3.15***	3.98***
Panel C: Joint Ventures and Strategic Alliances											
Total number of JVs and strategic alliances	9,249	0.83	0	2,840	1.40	0	6,409	0.58	0	8.21***	14.95***
Total number of JVs and strategic alliances with VC-backed firms	9,249	0.19	0	2,840	0.37	0	6,409	0.11	0	9.26***	15.55***

Table 7
VC Directors and Acquisitions

This table presents estimates of various models investigating the acquisition activity of our sample of public firms. Model (1) presents probit estimates for the likelihood of making acquisitions, where the dependent variable is equal to one if the firm makes an acquisition in a given year and to zero otherwise. Model (2) presents probit estimates for the likelihood of making acquisitions of VC-backed targets, where the dependent variable takes the value of one if a firm acquires at least one VC-backed target in a given year and zero otherwise. Model (3) replicates the analysis in model (2) for the subsample of firms which were not VC-backed at the time of their IPO. Model (4) shows probit estimates of the probability of a firm in our sample to acquire a VC-backed target conditional on making an acquisition, where the dependent variable takes the value of one if the target firm acquired is VC-backed and zero otherwise. *Presence of VC directors* is an indicator variable taking the value of one if the firm has at least one VC on its board and zero otherwise. *VC-backed at the time of IPO* is an indicator variable taking the value of one if the firm is VC-backed and zero otherwise. *VC density* is defined as the ratio of the number of VC firms in a given state to the number of public firms headquartered in that state. *R&D intensity* is the R&D outlay of the firm as a proportion of its market value of assets, *Board size* is the natural logarithm of the number of directors on board, *Firm size* is the natural logarithm of total assets, *Tobin's Q* is the ratio of market value of assets to book value of assets, *Leverage* is defined as interest bearing debt divided by total assets, *Firm public age* is the natural logarithm of the number of years since the firm's IPO, *Return on assets* is defined as the ratio of operating income before depreciation to total assets, *Intangible assets* is defined as total assets minus property, plant and equipment divided by total assets. The models include a constant term, year and industry fixed effects which are not reported. Industry dummies are assigned according to the Fama-French 48 industry groups. For each independent variable, the first row reports its estimated coefficient and the second row the corresponding z-statistic. All standard errors are heteroskedasticity-robust and are clustered at the firm level. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	Probit Model for making at least one acquisition	Probit Model for making at least one VC-backed target acquisition		Probit Model for the target firm being VC-backed
	All Sample Firms (1)	All Sample Firms (2)	NonVC-Backed Firms (3)	All Sample Firms (4)
Presence of VC directors (indicator)	0.043 0.63	0.125 1.78*	0.196 1.96**	0.329 2.49***
VC-backed at the time of IPO (indicator)	0.067 0.95	0.206 2.76***		0.134 1.81*
VC density	-0.574 -1.70*	0.146 0.39	0.091 0.16	1.803 2.80***
Presence of VC directors (indicator) * VC density				-1.442 -2.05**
R&D intensity	0.752 0.84	2.229 2.48**	-0.574 -0.26	3.151 2.87***
Board size	-0.114 -0.88	0.002 0.01	-0.191 -1.04	0.072 0.65
Firm size	0.318 11.63***	0.333 11.34***	0.279 7.07***	0.100 4.70***
Tobin's Q	-0.0198 -1.70*	0.009 0.81	0.027 1.13	0.007 1.52
Leverage	0.099 0.89	0.061 0.53	0.032 0.28	-0.145 -1.18
Firm public age	-0.156 -2.84***	-0.065 -1.10	-0.051 -0.67	0.044 0.80
Return on assets	0.237 0.81	-0.612 -1.96*	-1.129 -3.13***	-0.871 -2.43**
Intangible assets	0.970 4.19***	1.061 4.09***	1.091 3.03***	0.219 0.89
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
R^2/Pseudo R^2	0.1243	0.2059	0.1716	0.1212
Sample size	3,904	3,858	2000	3838

Table 8
Acquisitions Around VC Director Appointments and Departures

This table presents estimates of various models investigating the acquisition activity of a mature public firm in the period before and in the period after it appoints a VC director to its board. Model (1) presents probit estimates for the likelihood of making acquisitions, where the dependent variable is equal to one if the firm makes an acquisition in a given year and to zero otherwise. Model (2) presents probit estimates for the likelihood of making acquisitions of VC-backed targets, where the dependent variable takes the value of one if a firm acquires at least one VC-backed target in a given year and zero otherwise. Model (3) shows probit estimates of the probability of a firm in our sample to acquire a VC-backed target conditional on making an acquisition, where the dependent variable takes the value of one if the target firm acquired is VC-backed and zero otherwise. In models (4) and (5), we estimate an OLS model where the dependent variable is the logarithm of the number of VC-backed firms acquired by a firm in our sample in a given year. Model (6) replicates the analysis in model (4) for the subsample of firms which were not VC-backed at the time of their IPO. *Post-VC director appointment* is an indicator variable taking the value of one if a firm-year observation occurs in the period after the firm obtains a VC director and zero if the firm-year observation occurs in the period before the VC director appointment. *Post-VC director departure* is an indicator variable taking the value of one if a firm-year observation occurs in the period after the VC director leaves the board and zero if the firm-year observation occurs in the period before the VC director departure. *VC-backed at the time of IPO* is an indicator variable taking the value of one if the firm is VC-backed and zero otherwise. *VC density* is defined as the ratio of the number of VC firms in a given state to the number of public firms headquartered in that state. *R&D intensity* is the R&D outlay of the firm as a proportion of its market value of assets, *Board size* is the natural logarithm of the number of directors on board, *Firm size* is the natural logarithm of total assets, *Tobin's Q* is the ratio of market value of assets to book value of assets, *Leverage* is defined as interest bearing debt divided by total assets, *Firm public age* is the natural logarithm of the number of years since the firm's IPO, *Return on assets* is defined as the ratio of operating income before depreciation to total assets, and *Intangible assets* is defined as total assets minus property, plant and equipment divided by total assets. The models include a constant term which is not reported. For each independent variable, the first row reports its estimated coefficient and the second row the corresponding z-statistic. All standard errors are heteroskedasticity-robust and are clustered at the firm level. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	Probit Model for making at least one acquisition	Probit Model for making at least one VC-backed target acquisition	Probit Model for the target firm being VC-backed	Dependent variable: Logarithm of the number of VC-backed target acquisitions		
				All Sample Firms	All Sample Firms	NonVC-Backed Firms
	(1)	(2)	(3)	(4)	(5)	(6)
Post-VC director appointment (indicator)	0.049 0.14	0.757 1.53	0.827 2.38**	0.129 1.78*		0.103 2.22**
Post-VC director appointment (indicator) * VC density	-3.326 -1.55	-5.456 -2.04**	-5.493 -2.54***	-0.982 -2.12**		-0.824 -1.71*
Post-VC director departure (indicator)					-0.230 -2.01**	
Post-VC director departure (indicator) * VC density					1.055 1.60	
VC-backed at the time of IPO (indicator)	-0.047 -0.18	0.138 0.55	0.150 0.63	0.028 0.53	0.0970 1.14	
VC density	-0.605 -0.38	1.583 0.93	5.849 2.57***	0.507 1.38	-0.740 -1.40	0.642 1.08
R&D intensity	2.455 0.64	4.240 0.87	2.171 0.44	0.879 1.10	0.234 0.39	2.780 1.72*
Board size	-0.252 -0.47	-0.250 -0.43	-0.135 -0.20	-0.151 -1.43	-0.361 -2.65***	-0.047 -0.50
Firm size	0.630 4.03***	0.394 3.35***	0.132 0.93	0.104 2.92***	0.150 2.54**	0.060 1.96*
Tobin's Q	-0.072 -1.17	0.048 0.66	-0.020 -0.30	0.020 1.89*	0.0526 3.42***	0.008 0.52
Leverage	-0.047 -0.22	-1.737 -1.88*	-3.226 -2.47***	-0.036 -0.57	0.0285 0.26	-0.037 -0.65
Firm public age	-0.533 -2.15**	0.130 0.44	0.288 1.11	-0.046 -1.06	-0.0697 -1.57	-0.043 -1.06
Return on assets	-0.285 -0.25	-3.498 -1.94**	-2.087 -1.10	-0.485 -2.05**	-0.354 -1.17	-0.117 -0.37
Intangible assets	2.377 4.90***	1.476 2.53***	-0.549 -0.51	0.205 2.08**	0.621 2.69***	0.129 1.56
R^2/Pseudo R^2	0.2183	0.2928	0.2631	0.2747	0.3867	0.2162
Sample size	228	228	247	228	286	143

Table 9
VC Directors and Strategic Investment in VC-backed Firms

This table presents estimates of various models investigating the strategic investments undertaken by our sample of public firms. Model (1) shows probit estimates for the probability of collaborating with VC-backed partners in joint ventures (JVs) and strategic alliances where the dependent variable takes the value of one if a mature firm in our sample establishes at least one JV or strategic alliance with a VC-backed firm in a given year and is zero otherwise. Model (2) shows estimates for the determinants of the number of JVs and strategic alliances with VC-backed firms, where the dependent variable is the logarithm of the number of JVs and strategic alliances with VC-backed firms. Model (3) shows probit estimates for the probability of undertaking a corporate venture capital (CVC) investment where the dependent variable takes the value of one if the public firm invests in a VC-backed start-up and zero otherwise. Model (4) presents estimates for the total amount of CVC invested by the firm. *Presence of VC directors* is an indicator variable taking the value of one if the firm has at least one VC on its board and zero otherwise. *VC-backed at the time of IPO* is an indicator variable taking the value of one if the firm is VC-backed and zero otherwise. *VC density* is defined as the ratio of the number of VC firms in a given state to the number of public firms headquartered in that state. *R&D intensity* is the R&D outlay of the firm as a proportion of its market value of assets, *Board size* is the natural logarithm of the number of directors on board, *Firm size* is the natural logarithm of total assets, *Tobin's Q* is the ratio of market value of assets to book value of assets, *Leverage* is defined as interest bearing debt divided by total assets, *Firm public age* is the natural logarithm of the number of years since the firm's IPO, *Return on assets* is defined as the ratio of operating income before depreciation to total assets, and *Intangible assets* is defined as total assets minus property, plant and equipment divided by total assets. The models include a constant term, year and industry fixed effects which are not reported. Industry dummies are assigned according to the Fama-French 48 industry groups. For each independent variable, the first row reports its estimated coefficient and the second row the corresponding z-statistic. All standard errors are heteroskedasticity-robust and are clustered at the firm level. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	Probit Model for partnering with at least one VC-backed firm	Dependent variable: Logarithm of the number of JVs and alliances with VC-backed firms	Probit Model for undertaking CVC investments	Total CVC investment by the firm
	(1)	(2)	(3)	(4)
Presence of VC directors (indicator)	0.206 2.48***	0.036 2.14**	0.339 2.14**	0.109 2.83***
VC-backed at the time of IPO (indicator)	0.158 1.74*	0.024 1.59	0.021 0.13	0.004 0.10
VC density	1.154 2.57***	0.168 1.95**	2.991 4.83***	0.277 1.26
R&D intensity	4.592 4.75***	0.696 3.14***	7.749 4.03***	3.58 2.08**
Board size	-0.145 -0.84	-0.040 -1.01	0.483 1.69*	0.065 1.29
Firm size	0.365 10.56***	0.085 5.08***	0.591 9.93***	0.054 3.11***
Tobin's Q	-0.001 -0.06	0.003 0.91	-0.012 -0.64	0.011 1.13
Leverage	-0.092 -0.79	-0.059 -2.20**	-0.062 -0.30	-0.095 -1.86*
Firm public age	-0.044 -0.61	0.010 0.69	0.080 0.60	0.029 1.24
Return on assets	-0.112 -0.33	-0.104 -1.68*	-0.511 -0.73	-0.421 -2.13**
Intangible assets	0.397 1.32	0.067 1.74*	2.442 4.19***	0.045 0.57
Industry fixed effects	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes
R^2/Pseudo R^2	0.2744	0.2615	0.4085	0.0735
Sample Size	3,356	3,913	2,672	3,912

Table 10
Strategic Investment in VC-backed Firms Around VC Director Appointments and Departures

This table presents estimates of various models investigating the strategic investments undertaken by a mature public firm in the period before and in the period after it appoints a VC director to its board. Models (1a) and (1b) show probit estimates for the probability of collaborating with VC-backed partners in joint ventures (JVs) and strategic alliances where the dependent variable takes the value of one if a mature firm in our sample establishes at least one JV or strategic alliance with a VC-backed firm in a given year and is zero otherwise. Models (2a) and (2b) show estimates for the determinants of the number of JVs and strategic alliances with VC-backed firms, where the dependent variable is the logarithm of the number of JVs and strategic alliances with VC-backed firms. Model (3) shows probit estimates for the probability of undertaking a corporate venture capital (CVC) investment where the dependent variable takes the value of one if the public firm invests in a VC-backed start-up and zero otherwise. *Post-VC director appointment* is an indicator variable taking the value of one if a firm-year observation occurs in the period after the firm obtains a VC director and zero if the firm-year observation occurs in the period before the VC director appointment. *Post-VC director departure* is an indicator variable taking the value of one if a firm-year observation occurs in the period after the VC director leaves the board and zero if the firm-year observation occurs in the period before the VC director departure. *VC-backed at the time of IPO* is an indicator variable taking the value of one if the firm is VC-backed and zero otherwise. *VC density* is defined as the ratio of the number of VC firms in a given state to the number of public firms headquartered in that state. *R&D intensity* is the R&D outlay of the firm as a proportion of its market value of assets, *Board size* is the natural logarithm of the number of directors on board, *Firm size* is the natural logarithm of total assets, *Tobin's Q* is the ratio of market value of assets to book value of assets, *Leverage* is defined as interest bearing debt divided by total assets, *Firm public age* is the natural logarithm of the number of years since the firm's IPO, *Return on assets* is defined as the ratio of operating income before depreciation to total assets, and *Intangible assets* is defined as total assets minus property, plant and equipment divided by total assets. The models include a constant term which is not reported. For each independent variable, the first row reports its estimated coefficient and the second row the corresponding z-statistic. All standard errors are heteroskedasticity-robust and are clustered at the firm level. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	Probit Model for partnering with at least one VC-backed firm		Dependent variable: Logarithm of the number of JVs and alliances with VC-backed firms		Probit Model for undertaking CVC investments
	(1a)	(1b)	(2a)	(2b)	(3)
Post-VC director appointment (indicator)	0.461 1.08		0.062 1.16		0.893 1.76*
Post-VC director appointment (indicator) * VC density	-4.924 -2.22**		-0.643 -2.17**		-2.879 -1.40
Post-VC director departure (indicator)		-1.427 -3.26***		-0.298 -2.55***	
Post-VC director departure (indicator) * VC density		4.428 2.13**		0.849 1.49	
VC-backed at the time of IPO (indicator)	0.641 2.15**	0.189 0.72	0.093 2.22**	0.0358 0.60	1.286 3.77***
VC density	3.216 1.64*	-3.949 -1.97**	0.522 2.11**	-0.879 -1.45	3.281 1.35
R&D intensity	6.039 1.33	-0.540 -0.20	1.027 1.49	-0.144 -0.23	21.166 3.18***
Board size	-1.121 -2.14**	-0.0540 -0.08	-0.173 -2.18**	0.0907 0.67	-1.372 -1.91*
Firm size	0.267 2.53***	0.319 3.05***	0.064 2.64***	0.0731 2.95***	0.465 2.70***
Tobin's Q	-0.021 -0.41	-0.00403 -0.07	-0.009 -0.94	0.0228 1.29	-0.059 -0.71
Leverage	0.099 0.27	-1.185 -1.68*	0.028 0.84	-0.123 -0.92	-3.281 -2.14**
Firm public age	0.363 1.63*	0.114 0.51	0.025 0.87	-0.000874 -0.02	-0.332 -0.83
Return on assets	-0.439 -0.32	-0.123 -0.12	-0.073 -0.43	0.00306 0.01	4.104 3.11***
Intangible assets	1.235 2.19**	3.779 2.84***	0.025 0.38	0.684 2.79***	1.502 1.32
R^2/Pseudo R^2	0.2562	0.2117	0.2243	0.2309	0.4122
Sample Size	228	286	228	286	228

Table 11
VC Directors and Announcement Returns Around Acquisitions and Strategic Investments

This table presents the cumulative abnormal returns (CAR) around the announcement dates of major corporate events, including mergers and acquisitions (M&As), joint ventures (JVs) and strategic alliances, and corporate venture capital (CVC) investments. Abnormal returns are calculated using the standard event study methodology of Brown and Warner (1985). CARs of the firms are calculated for the three-day event windows (-1,+1) around the event announcement date, where day 0 corresponds to the announcement day. The parameters of the market model, which uses the CRSP value-weighted market return, are estimated over the interval from 210 to 30 days prior to the announcement date. ***, ** and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	Before the VC director appointment			After the VC director appointment			Comparison of CARs between before and after periods
	N	Mean CAR	Patell Z Statistic	N	Mean CAR	Patell Z Statistic	p-value
M&As	396	-0.16%	-0.994	215	0.18%	1.497*	0.1873
M&As with VC-backed firms	74	-1.52%	-2.703***	55	0.09%	-0.246	0.0325
M&As with nonVC-backed firms	338	0.13%	0.104	174	0.28%	2.167**	0.5624
JVs & Alliances	318	0.07%	0.723	135	0.11%	1.268	0.8336
CVC investments	60	-0.14%	0.136	28	0.14%	0.548	0.7242

Table 12
VC Directors and Acquirer Announcement Returns Around M&A Announcements

This table presents the regression estimates for the determinants of the cumulative abnormal returns (CARs) of the sample firms around the announcement dates of mergers and acquisitions (M&As). Model (1) uses full sample, whereas Models (2) and (3) use the subsample of firms which experience the arrival of a VC director. The dependent variable is the acquirer's CAR over the window (-1,+1) around the announcement day. Abnormal returns are calculated using the standard event study methodology of Brown and Warner (1985) for the three-day event windows (-1,+1) around the event announcement date, where day 0 corresponds to the announcement day. The parameters of the market model, which uses the CRSP value-weighted market return, are estimated over the interval from 210 to 30 days prior to the announcement date. *VC-backed target firm* is an indicator variable taking the value of one if the target firm was VC-backed at its IPO and zero otherwise. *Presence of VC directors* is an indicator variable taking the value of one if the firm has at least one VC on its board and zero otherwise. *M&A after VC appointment* is an indicator variable which takes the value of one if the M&A deal takes place after the appointment of the VC director and zero otherwise. *VC density* is defined as the ratio of the number of VC firms in a given state to the number of public firms headquartered in that state. *Stock_financed* is an indicator variable taking the value of one if the M&A deal is financed by stock and zero otherwise. *Private target* is an indicator variable taking the value of one if the target firm is private and zero otherwise. *Diversifying acquisition* is an indicator variable taking the value of one if the acquirer and the target firm are not in the same Fama-French 48 industry group and zero otherwise. *Firm size* is the natural logarithm of total assets, *Tobin's Q* is the ratio of market value of assets to book value of assets, *Leverage* is defined as interest bearing debt divided by total assets, *Return on assets* is defined as the ratio of operating income before depreciation to total assets. *Relative deal size* is the ratio of the size of the M&A deal to the size of the acquirer, *M&A intensity in target industry* is the total M&A volume in target firm's industry in a year normalized by the total value of assets in that industry-year, and *Tender offer (Hostile offer)* is an indicator variable taking the value of one if the acquisition follows a tender offer (hostile offer) and zero otherwise. The models also include a constant term, year and industry fixed effects which are not reported. Industry dummies are assigned according to the Fama-French 48 industry groups. For each independent variable, the first row reports its estimated coefficient and the second row the corresponding t-statistic. All standard errors are heteroskedasticity-robust and are clustered at the firm level. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	(1)	(2)	(3)
VC-backed target firm (indicator)	-0.007 -2.15**	-0.028 -2.54***	-0.028 -2.46**
Presence of VC directors (indicator)	-0.003 -1.14		
Presence of VC directors * VC-backed target firm (indicator)	0.003 0.66		
M&A after VC appointment (indicator)		-0.007 -0.56	-0.017 -0.97
M&A after VC appointment * VC-backed target firm (indicator)		0.037 2.24**	0.036 2.17**
VC density			-0.021 -0.29
M&A after VC appointment (indicator) * VC density			0.053 0.84
Stock_financed (indicator)	-0.015 -5.61***	-0.008 -0.87	-0.007 -0.72
Private target (indicator)	0.002 1.12	0.011 1.33	0.011 1.33
Diversifying acquisition (indicator)	-0.004 -1.89*	-0.020 -2.53***	-0.021 -2.57**
Firm size	-0.002 -3.08***	-0.003 -0.89	-0.004 -1.01
Tobin's Q	0.002 2.57***	-0.002 -0.86	-0.002 -0.83
Leverage	0.010 1.27	-0.032 -0.91	-0.032 -0.90
Return on assets	0.005 0.17	-0.031 -0.27	-0.039 -0.33
Relative deal size	-0.028 -5.11***	-0.123 -6.31***	-0.124 -6.31***
M&A intensity in target industry	0.010 0.7	0.013 0.2	0.012 0.18
Tender offer (indicator)	-0.007 -1.75*	0.018 1.32	0.018 1.35
Hostile offer (indicator)	-0.030 -1.24		
Industry fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes
Adjusted R^2	0.0286	0.2163	0.2117
Sample Size	3,739	241	241

Table 13
VC Directors and Operating Performance

This table shows the estimation results of the OLS regressions for the operating performance of our sample of firms measured by return on assets (ROA) and return on sales (ROS). The dependent variables *ROA (ROS)*, is defined as the ratio of operating income before depreciation to total assets (total sales). *Post-VC director appointment* is an indicator variable taking the value of one if a firm-year observation occurs in the period after the firm obtains a VC director and zero if the firm-year observation occurs in the period before the VC director appointment. *Post-VC director departure* is an indicator variable taking the value of one if a firm-year observation occurs in the period after the VC director leaves the board and zero if the firm-year observation occurs in the period before the VC director departure. *VC-backed at the time of IPO* is an indicator variable taking the value of one if the firm is VC-backed and zero otherwise. *VC density* is defined as the ratio of the number of VC firms in a given state to the number of public firms headquartered in that state. *R&D intensity* is the R&D outlay of the firm as a proportion of its market value of assets, *Board size* is the natural logarithm of the number of directors on board, *Firm size* is the natural logarithm of total assets, *Tobin's Q* is the ratio of market value of assets to book value of assets, *Leverage* is defined as interest bearing debt divided by total assets, *Firm public age* is the natural logarithm of the number of years since the firm's IPO, *Intangible assets* is defined as total assets minus property, plant and equipment divided by total assets, and *5-year post-IPO return* is the 5-year return of the public firm right after its IPO. *State per capita income* is the per capita income in the state of the firm, *State educational attainment* is defined as the percentage of the population age 25 and over with a bachelor's degree or more, and *State R&D per capita* is the total R&D expense per capita in the state of the firm. For each independent variable, the first row reports its estimated coefficient and the second row the corresponding t-statistic. All standard errors are heteroskedasticity-robust and are clustered at the firm level. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	ROA		ROS	
	(1)	(2)	(3)	(4)
Post-VC director appointment (indicator)	0.057 2.25**		0.070 1.92*	
Post-VC director appointment (indicator) * VC density	-0.260 -1.90*		-0.249 -1.98*	
Post-VC director departure (indicator)		0.020 0.76		0.053 1.15
Post-VC director departure (indicator) * VC density		0.0789 0.53		0.254 1.05
VC-backed at the time of IPO (indicator)	-0.010 -0.47	0.028 1.67	0.099 3.13***	0.028 0.64
VC density	0.206 1.06	-0.249 -1.53	0.158 0.70	-0.284 -1.32
R&D Intensity	-0.015 -3.88***	-0.006 -2.84***	-0.019 -3.43***	-0.008 -1.89*
Board size	-0.005 -0.13	-0.089 -2.25**	-0.018 -0.43	-0.074 -0.89
Firm size	-0.018 -1.43	0.026 4.48***	-0.002 -0.11	0.045 3.42***
Tobin's Q	0.025 3.07***	0.009 2.22**	0.010 2.23**	0.011 1.87*
Leverage	0.097 3.55***	-0.127 -4.14***	0.014 0.71	-0.135 -1.68
Firm public age	0.046 2.06**	0.005 0.28	0.039 1.06	0.016 0.35
Intangible assets	0.012 0.23	-0.202 -3.27***	0.019 0.37	-0.071 -0.50
5-year post-IPO return	-0.007 -1.07	-0.001 -0.97	0.001 0.12	-0.006 -1.48
State per capita income	-0.002 -0.62	-0.001 -0.45	-0.002 -0.39	-0.001 -0.12
State educational attainment	-0.473 -1.21	0.295 1.62	0.161 0.23	-0.072 -0.18
State R&D per capita	-0.005 -0.31	-0.033 -3.64***	-0.009 -0.46	-0.047 -2.40**
Adjusted R^2	0.5540	0.4431	0.3104	0.3182
Sample size	206	260	206	260

Table 14
Announcement Return Regressions Around New Director Appointments

This table presents the regression estimates for the determinants of the cumulative abnormal returns (CARs) of the sample firms around the announcement dates of new director appointments. The dependent variable is the firm's CAR around the announcement day of a director appointment. Abnormal returns are calculated using the standard event study methodology of Brown and Warner (1985) for the event window (-1,0) around the event announcement date, where day 0 corresponds to the announcement day. The parameters of the market model, which uses the CRSP value-weighted market return, are estimated over the interval from 210 to 30 days prior to the announcement date. *Appointment of a VC director* is an indicator variable taking the value of one if the appointed director is a VC and zero otherwise. *R&D intensity* is the R&D outlay of the firm as a proportion of its market value of assets. *VC density* is defined as the ratio of the number of VC firms in a given state to the number of public firms headquartered in that state. *Proportion of VC directors on board* is the ratio of the number of VC directors on board to the total number of directors on board, *Board size* is the natural logarithm of the number of directors on board, *Firm size* is the natural logarithm of total assets, *Tobin's Q* is the ratio of market value of assets to book value of assets, *Leverage* is defined as interest bearing debt divided by total assets, *Return on assets* is defined as the ratio of operating income before depreciation to total assets, *Increase in board size* takes the value of one if there in an increase in board size and zero otherwise. For each independent variable, the first row reports its estimated coefficient and the second row the corresponding t-statistic. All standard errors are heteroskedasticity-robust and are clustered at the firm level. ***, **, and * indicate statistical significance at the 1%, 5% and 10% level, respectively.

	(1)	(2)
Appointment of a VC director (indicator)	0.018 2.70***	0.005 0.55
Appointment of a VC director * R&D intensity	-0.565 -2.69***	-0.575 -2.69***
R&D intensity	0.100 0.96	0.069 0.57
VC density		0.031 0.96
Appointment of a VC director * VC density		0.102 1.95*
Proportion of VC directors on board	0.048 1.62	
Board size	0.001 0.10	
Firm size	0.0005 0.30	0.0003 0.16
Tobin's Q	0.0008 0.80	0.0009 0.97
Leverage	0.008 0.72	0.010 1.06
Return on assets	-0.029 -1.10	-0.030 -1.20
Increase in board size (indicator)	0.006 1.20	
Adjusted R^2	0.0170	0.0226
Sample Size	308	308