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The Effects of Corporate Venture Capital, Founder Incumbency, and Their Interaction on Entrepreneurial Firms' R&D Investment Strategies

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Abstract. Corporate venture capital (CVC) investment has increasingly become an important source of entrepreneurial finance. Accordingly, while scholars have traditionally focused on understanding the main motivations behind CVC activity and its impact on the investing corporate firm, more recently, scholars have also started to emphasize the importance of understanding the impact of CVC investment on the investee venture. In particular, these recent studies commonly show that CVC investment has a positive effect on the venture's innovation. While the positive link between CVC investment and the venture's innovation output is well established in the literature, the organizational mechanisms through which this relationship unfolds within the venture remain relatively underexplored. In this study, we fill this gap in the literature by examining the effects of CVC ownership, founder incumbency, and the CVC investor–founder interaction on research and development (R&D) investment strategies in venture capital (VC)-financed, technology-based entrepreneurial ventures. In doing so, we aim to provide a novel explanation of the organizational mechanisms that lead to greater investment in research and development (R&D), especially with regard to the interaction between CVC investors and founder managers. We argue that CVC ownership and founder incumbency positively affect entrepreneurial firms' R&D investment and, more importantly, that the CVC ownership effect is effectively amplified when the founder is an incumbent top manager because of goal congruence and knowledge spillover from the CVC firm. Our empirical analysis supports our hypotheses while addressing potential endogeneity concerns. Our results also support various mechanisms by utilizing the data on CVC investor's board membership, CVC investor heterogeneity, the founder's technological background, and the investee venture's industry.

Supplemental Material: The online appendix is available at https://doi.org/10.1287/orsc.2017.1133.

Keywords: corporate venture capital (CVC) • founder • R&D investment • knowledge spillover • entrepreneurship • corporate governance

Introduction

Corporate venture capital (CVC) investment has increasingly become an important source of entrepreneurial finance,[1] which affects the ownership structure of a venture. Accordingly, while scholars have traditionally focused on understanding the main motivations behind CVC activity and its impact on the investing corporate firm (e.g., Basu et al. 2011; Dushnitsky and Lenox 2005a, b, 2006; Wadhwa and Kotha 2006), more recently, scholars have also started to emphasize the importance of understanding the impact of CVC investment on the investee venture (e.g., Alvarez-Garrido and Dushnitsky 2016, Chemmanur et al. 2014, Pahnke et al. 2015a, Park and Steensma 2013). In particular, these recent studies commonly show that CVC investment has a positive effect on the venture's innovation as measured in patents and other industry-specific innovation measures, such as U.S. Food and Drug Administration (FDA) product approvals (Pahnke et al. 2015a) and scientific publications (Alvarez-Garrido and Dushnitsky 2016). Therefore, the positive link between CVC investment and the venture's innovation output seems to be well documented in the literature. However, the organizational mechanisms through which this relationship unfolds within the venture remain relatively underexplored.

For multiple reasons, addressing this gap is important to advancing our knowledge of entrepreneurship and innovation. First, given that CVC firms and independent venture capital (IVC) firms both provide financial resources that can be used toward an entrepreneurial firm's research and development (R&D), this gap in the literature still leaves us wondering why and how financial resources provided by CVC firms in particular lead to more innovation compared with those provided solely by IVC firms. Second, because of the inherent CVC investor–founder tension that stems from technology misappropriation

hazards (Dushnitsky and Shaver 2009, Katila et al. 2008) and the emergence of CVC investment as a major source of entrepreneurial finance, it has become increasingly important to understand the interrelation between CVC investors and founders ex post funding that leads to more investment in R&D. Finally, a better understanding of the dynamics among the main stakeholders—CVC investors, IVC investors, and founders—that govern the entrepreneurial firm has broader implications for managerial practice and the literature on entrepreneurial finance and corporate governance.

The purpose of this study is thus to fill this gap in the literature by examining the effects of CVC ownership, founder incumbency, and the CVC investor–founder interaction on research and development (R&D) investment strategy in venture capital (VC)-financed, technology-based entrepreneurial ventures. In doing so, we aim to provide a novel explication of the organizational mechanisms that lead to greater investment in R&D,[2] especially with regard to the interaction between CVC investors and founder managers. Investment in R&D is inherently a high-risk, high-return strategy for resource-constrained entrepreneurial firms, which requires constant support from shareholders and top managers (e.g., chief executive officers (CEOs)) (Aghion et al. 2013). In fact, given that each stakeholder may have different preferences toward R&D, some stakeholders may prefer to allocate more resources to commercialization than to innovation. Thus, in our study, R&D investment serves as both an *input* measure for technological innovation and a long-term *strategic resource allocation decision* that reflects the tensions among the three principal actors (i.e., IVC investors, CVC investors, and founders) that stem from heterogeneous preferences.

We use insights from the technology entrepreneurship literature on CVC (e.g., Dushnitsky and Lenox 2005a, Park and Steensma 2012) and the founder-manager literature (e.g., Boeker and Karichalil 2002, Wasserman 2003) to form testable hypotheses. Although these two streams of literature have been largely developed in isolation to date, we consider them both separately and jointly to present our theoretical argument. In the following sections, we first articulate the mechanisms that underlie the main effects of CVC ownership and founder incumbency on a venture's R&D investment strategy to form our baseline hypotheses. We then pose an integrated theoretical argument on the novel mechanism that underlies the interrelationship of these two effects. Using a sample of VC-backed ventures in technology-intensive industries that vary in degree of CVC ownership and with regard to whether the founder was an incumbent manager, we find that CVC ownership and founder incumbency positively affect R&D intensity (i.e., R&D investment normalized by firm size) in entrepreneurial ventures. More importantly, compared with the canonical CVC investor–entrepreneur conflict (e.g., Dushnitsky and Lenox 2005a, b) and the established firm's knowledge acquisition strategy via CVC investment (e.g., Dushnitsky and Shaver 2009, Smith and Shah 2013), which are commonly emphasized in the literature, we find that the above-mentioned positive CVC ownership effect is effectively amplified when the founder is an incumbent top manager because of goal congruence and knowledge spillover[3] that stem from the CVC investor. Our results remain robust even after potential endogeneity concerns are addressed.

Our work is closely related to that of Alvarez-Garrido and Dushnitsky (2016) and that of Chemmanur et al. (2014), who show that CVC-funded ventures exhibit greater innovation. Chemmanur et al. (2014) suggest that CVC investor's greater tolerance for failure and greater industry knowledge are two possible mechanisms that enable CVC-funded ventures to have more patents than IVC-only-funded ventures. Based on their study of biotech firms, Alvarez-Garrido and Dushnitsky (2016) suggest that an investee venture's access to complementary assets that the CVC firm's parent company possesses may be the main contributing factor to the investee venture's greater innovation output. Our study importantly complements these studies by using R&D intensity as the dependent variable and by showing that the positive effect of CVC investment on a venture's greater innovation output is realized via greater resource allocation to R&D activities. Thus, this study contributes to the literature by uncovering the organizational mechanisms that underlie the CVC investor–founder interaction ex post funding, which leads to greater investment in R&D, and joins the emerging literature on CVC from the investee's perspective (e.g., Alvarez-Garrido and Dushnitsky 2016, Pahnke et al. 2015a).

Theory and Hypotheses

In a standard VC model, IVC firms raise capital from limited partners to form VC funds, which typically have a fixed life of 10 years, to invest in high-risk, high-return ventures with the goal of generating substantial financial returns. By contrast, CVC firms are typically structured as subsidiaries of incumbent corporations, and they procure the funds for their investments from their parent corporations, do not adopt high-powered, performance-based compensation schemes (e.g., carried interest), and take a minority equity stake in privately held entrepreneurial ventures. As strategic investors, CVC firms pursue strategic benefits in addition to financial returns from their investment in ventures. Above all, they prioritize leveraging investments to acquire new technologies that emerge from new ventures, thereby gaining a "window" on new technologies (Benson and Ziedonis 2009). Therefore, CVC

investors are incentivized to support the portfolio company's continued R&D efforts so that strategic benefits can be maximized.

The CVC Ownership Effect

CVC investors can drive investee firms' investment in R&D in several ways. First, CVC investors with significant ownership are more likely to maintain a board seat and influence the venture's strategic direction (*direct corporate governance effect*). When CVC firms invest in an entrepreneurial venture, they typically coinvest with IVC firms, forming a VC syndication (Lerner 1994). However, IVC firms and CVC firms have different primary investment objectives, which may lead to a potential conflict of interest. Because R&D investment does not always increase firm value in the short run, IVC firms may not fully support substantial R&D, especially as they approach the end of their investment cycle. By contrast, CVC firms have less time constraints in their investment horizon and often regard CVC investment as "R&D outsourcing" (Basu et al. 2011). Accordingly, CVC firms may support the venture in continuously investing in an R&D project if new knowledge stemming from it could benefit the CVC firm's parent company's core business. This CVC–IVC investors conflict stemming from a difference in investment objectives can become particularly salient if the venture approaches a major liquidity event (e.g., an initial public offering (IPO)).[4] Thus, when CVC investors hold greater ownership, they are more likely to directly influence strategic issues that require the board's approval (e.g., resource allocation decisions) and to implement broader interventions that counterbalance the IVC firm's preferences. In practice, as CVC ownership constitutes a greater share of the total investment, a CVC firm is more likely to obtain observer seats, secure protective provisions (i.e., veto rights), and even obtain voting seats with control rights.[5]

Second, direct interactions with the CVC firm and its corporate parent can affect a portfolio company's R&D investment strategy (*CVC investor–venture interaction effect*). With a greater ownership stake in portfolio companies, the CVC firm's parent corporation is more likely to provide its portfolio companies with support to access complementary assets that facilitate commercialization (Gans et al. 2002, Teece 1986) or to share information with its portfolio companies. Such support can help entrepreneurial ventures save time and resources and can encourage them to focus more on technology development.

Finally, in some cases, CVC investors can resolve the risk and uncertainty regarding the ultimate acceptance of an entrepreneurial firm's novel technology as an industry standard. Relative to established firms, ventures that are developing novel technologies suffer from greater uncertainty because of their lack of legitimacy (Zimmerman and Zeitz 2002) and may hesitate to fully commit their resources to R&D. However, when an established incumbent backs the venture's technology with a significant ownership stake, the widespread uncertainty can be significantly reduced because of a *technology endorsement effect*, which is an important resource for young ventures that IVC firms cannot offer.[6] When the incumbent corporation is also a downstream customer, it is even easier for the venture to invest more in R&D because CVC investment practically secures a built-in buyer. Thus, unlike the support of IVC investors, the support of CVC investors can benefit entrepreneurial firms in both the *investment* and *product* markets. All told, as CVC ownership in a venture increases, the venture will be more likely to focus on spending more of its resources on R&D rather than on activities related to commercialization. We thus suggest the following as our first hypothesis:

Hypothesis 1 (H1). *Greater CVC ownership of an entrepreneurial venture is positively associated with the entrepreneurial venture's R&D intensity.*

The Founder Incumbency Effect

Founder managers are systematically different from professional agent managers, who are almost always brought in from outside the firm (Souder et al. 2012). The differences between the two types of managers are particularly striking in entrepreneurial firms (Wasserman 2006). For example, founders possess more entrepreneurial passion (Cardon et al. 2009), have a strong sense of attachment to the firm (Wasserman 2006), and consider "psychic income" to be as important as financial returns (Gimeno et al. 1997). Founders also differ substantially from agent managers regarding knowledge, values, and attitudes (Jayaraman et al. 2000). In essence, founder managers have a stronger commitment to their firms and may have a longer investment horizon compared with agent managers, who typically have relatively short-term contracts. Arthurs and Busenitz (2003) refer to founders' special commitment as the "ownership plus" mentality. Although their actual ownership percentage is diluted with each round of fundraising, founders will likely continue to perceive a greater level of ownership and to make nonfinancial investments of time, energy, and sweat equity.

In technology-intensive industries, because founders generally base their businesses on novel technological ideas, founders may have a propensity to invest more in developing their technology. From the founders' perspective, the quality of the product or the underlying technologies that their firm possesses is critical because such quality is considered to reflect their own capabilities and accomplishments in the market (Cardon et al. 2012). At the same time, because founders expect to remain with the venture longer than agent managers do, founders may invest in relatively longer-term projects or more radical innovation projects that

require more investment in R&D. However, founders' R&D investment preferences can be reflected in firm strategy only when founders are incumbent top managers (e.g., CEOs or chief technology officers (CTOs) in our context[7]). In other words, founders can exert their influence on firm strategy as long as they have legitimacy and structural power based on hierarchical authority (Finkelstein 1992). For instance, Google cofounders Sergey Brin and Larry Page actively participated in the firm's strategic decision making by assuming the roles of president of technology and president of product management, respectively, even after stepping down as CEOs and bringing in a more seasoned executive manager, Eric Schmidt. Thus, we suggest the following hypothesis:

Hypothesis 2 (H2). *A founder as an incumbent top manager of the venture is positively associated with the entrepreneurial venture's R&D intensity.*

Interrelation Between CVC Ownership and Founder Incumbency

We now jointly consider the arguments from the two preceding sections—the CVC ownership effect and the founder incumbency effect—to provide an integrative framework regarding the interrelationship between the investing CVC firm and the incumbent founder manager of the portfolio company. In doing so, we outline our argument that the positive effect of CVC ownership on the venture's R&D intensity (see Hypothesis 1) can be effectively amplified when the founder is an incumbent top manager of the entrepreneurial venture.

We previously highlighted three primary mechanisms through which greater CVC ownership can influence the investee company's R&D investment strategy: (i) the direct corporate governance effect, (ii) the CVC investor–venture interaction effect, and (iii) the technology endorsement effect. While the technology endorsement effect works primarily through external market signaling (and is thus irrelevant with regard to whether the founder is an incumbent top manager), the other two effects enhance R&D investment through mechanisms internal to the investee firm and thus may depend on whether the founder is an incumbent top manager. As such, we begin by noting that CVC investment provides opportunities for investee companies to benefit from knowledge spillover, which becomes a significant source of innovation, when the CVC investor sits on the investee venture's board or when the venture interacts with the CVC firm's parent company or other key industry players introduced by the CVC investor.

Knowledge spillover can occur in several ways, including the transmission of both firsthand knowledge originating from the CVC firm and secondary knowledge facilitated by the CVC firm's support. For example, knowledge spillover can occur when the venture's top managers interact with CVC investors during board meetings (e.g., in the form of advice, feedback, and open discussions) or when they interact with the CVC firm's parent company's developers (i.e., scientists and engineers), legal experts, marketing managers, or other key personnel. These interactions may include product testing, brainstorming, and other formal or informal conversations that provide various forms of technological and market knowledge feedback. In some cases, these interactions may even include "information leakage" that is brokered by the CVC firm, which retransmits knowledge about another portfolio company's technology (Pahnke et al. 2015b). In addition, knowledge spillover can occur when top managers of portfolio companies attend CVC-sponsored annual conferences (e.g., Intel Global Summit) or participate in other forms of CVC-sponsored start-up assistance programs (e.g., the Bridge by Coca-Cola). Furthermore, our interviews with industry practitioners repeatedly indicate the importance of "secondary knowledge spillover" from other portfolio companies, which top managers obtain when attending these programs for their innovation projects. This type of spillover is consistent with the notion of "informal" know-how trading, which is traditionally documented in the literature (von Hippel 1987). During our interviews, CVC investors also reported that their value-adding role includes serving as an intermediary or liaison between their portfolio companies and the CVC firm's parent company's suppliers, customers, and other key industry players. Thus, knowledge spillover can also occur through interactions with various types of industry players that CVC investors introduce to the portfolio company. In sum, CVC investment presents ample opportunities for knowledge spillover, and as CVC ownership of the venture increases, the likelihood that such knowledge spillover via various sources will occur more broadly and more frequently increases.

When investee ventures are exposed to various sources of knowledge spillover, founder managers can have a systematically different approach to the use of knowledge spillover compared with that of professional agent managers. When we compare founder managers with professional agent managers, who are mostly recruited in the later stages of a venture for their superior general management skills and who have relatively short fixed-term contracts, above all, founder managers are essentially entrepreneurs. Entrepreneurs can identify entrepreneurial opportunities more effectively (Baron 2006), have better risk-bearing capacities (Sarasvathy et al. 1998), and possess more tacit knowledge about the venture's technology (Koskinen and Vanharanta 2002) than professional agent managers. In addition, as mentioned earlier, founder managers of technology-based ventures support product development more than any other endeavor (Wasserman

2003). Therefore, because of differences in the predispositions, key strengths, and investment horizons of founder managers and professional agent managers, "selective attention" (Mack and Rock 1998, Neisser 1967, Treisman 1969, Treisman and Gelade 1980) may play a role when these top managers are exposed to various sources of CVC-induced knowledge spillover. In other words, as the recipients of knowledge spillover, founder managers of technology-based ventures may pay more attention to knowledge that pertains to product and technology development, while professional agent managers may pay more attention to knowledge that pertains to building the organization and driving financial results in preparation for a major liquidity event (e.g., an IPO).

With the aid of newly acquired knowledge, founder managers of technology-based ventures may invest more in technology and innovation—both in quantity and in quality—than professional agent managers. Because of the above-mentioned entrepreneurial traits, while interacting with CVC investors and other industry participants, founder managers may more easily recognize lucrative innovation projects that are worth pursuing, which may be manifested in the initiation of new R&D endeavors.[8] At the same time, founders naturally expect to remain with the venture for a sufficiently long time to reap the benefits of R&D investment. Thus, in addition to initiating more innovation projects when utilizing knowledge spillover from CVC investors, founder managers may engage in certain types of projects that differ from those initiated by professional agent-mangers. For example, longer-term innovation projects that may be potentially more radical can be an attractive option for founder managers, though perhaps less so for professional agent managers.

Because of goal congruence, as CVC ownership in the venture increases, the entrepreneurial venture will be more likely to actually pursue the innovation project that has been initiated by the founder manager. Professional agent managers, who are typically brought in by IVC investors, have goals that are congruent with those of IVC firms in terms of maximizing financial returns. However, with regard to R&D, founder managers and CVC firms may have goal congruence in terms of greater investment in R&D, as CVC investors are constantly seeking new knowledge through their investments (Dushnitsky and Lenox 2005a, b). CVC firms also have greater tolerance for failure (Chemmanur et al. 2014, Manso 2011) relative to IVC firms because of the differences in how CVC funds are structured and how CVC fund managers are compensated (Dushnitsky and Shapira 2010). Furthermore, goal congruence and the CVC investor's greater ownership in the venture also imply that any conflicting preferences of IVC investors will be more likely to be counterbalanced because of the coalition between the founder manager and the CVC investor. By contrast, when the CVC firm's ownership stake is not significant enough, counterbalancing the IVC firm's preferences may not be feasible. In sum, when the founder is an incumbent top manager and a CVC firm has a significantly large ownership stake in the venture, longer-term projects that pursue relatively radical innovation are more likely to be proposed and funded, which may require a greater resource commitment to R&D.

Hence, we expect the positive effect of CVC ownership on a venture's R&D intensity, as outlined in H1, to be greater when the founder is an incumbent top manager in the entrepreneurial venture because the amount and the type of innovation projects can differ based on the founder's utilization of knowledge spillover and the goal congruence between founder managers and CVC investors.[9] We propose the following hypothesis and present Table 1, which summarizes our integrative framework:

Hypothesis 3 (H3). *The positive relationship between CVC ownership and the entrepreneurial venture's R&D intensity is stronger when the founder is an incumbent top manager.*

Methods

Sample

To test our hypotheses, we collect data to construct our measures primarily from VentureXpert, Compustat (e.g., financial information), and Form S-1, which is a document that all public companies must file to register their securities with the U.S. Securities and Exchange Commission (e.g., ownership data). We use data from VentureXpert to establish the sample; these data have been extensively used in the CVC literature (e.g., Benson and Ziedonis 2010, Dushnitsky and Shaver 2009). The sample consists of VC-backed U.S. entrepreneurial firms that went public during the 2002–2011 period. For this period, the sample includes a variety of entrepreneurial firms that were founded before and after the Internet bubble period (i.e., the 1998–2001 period), including ventures that were first founded as early as 1986 or as late as 2009. In this

Table 1. Two-by-Two Summary Table of the Theoretical Framework

	H2	
DV: *R&D intensity*	Founder incumbency = **1**	Founder incumbency = **0**
H1		
CVC ownership HIGH	++	+
CVC ownership LOW	+	·

Note. ++ represents the CVC investor–founder interaction effect hypothesized in H3, and · represents the baseline.

period, CVC activity became prevalent (Gaba and Meyer 2008), and our sample includes both IVC-only-funded ventures and CVC-funded ventures. VC firms usually coinvest with CVC firms (93% of the time in our sample).

Because our outcome variable relies on firms' R&D expenditures and because such information is publicly available only when a venture goes public, we inevitably must rely on VC-backed ventures that eventually went public. Additionally, our sample consists of such ventures because both of our independent variables (*CVC ownership* and *founder incumbency*) can be identified only when these ventures file Form S-1 upon going public. In addition, by the time that a venture goes public, both founder-led and nonfounder-led ventures exist in the population, allowing us to test the founder incumbency effect (H2). We mainly rely on information revealed during the IPO process, which corresponds with data when the venture was a *private* firm (i.e., prior to the IPO year). We do not use data after an IPO because a venture's ownership structure vastly changes when investors such as IVC firms and CVC firms liquidate their shares after the post-IPO lockup period (Arikan and Capron 2010), which would render the setting inappropriate for our study. Thus, while the sample consists of ventures that eventually go public, the data capture the year that these ventures were actually private. However, to avoid potential sample selection bias caused by analyzing only ventures that reach an IPO, we supplement our main results with an analysis of non-IPO ventures, albeit with some data restrictions. We will return to this issue below.

Because our research focuses on R&D investment, we examine ventures from technology-intensive sectors, such as the information and communication technology (ICT) sector and the medical/health/life science sector (e.g., biotechnology and pharmaceutical firms; henceforth, the "BT sector"), according to the VentureXpert industry classification, and we exclude nontechnology-oriented firms. These industries are R&D-intensive industries, which are appropriate for our purposes and contain the vast majority of VC-backed ventures. In addition, to focus on entrepreneurial ventures, we limit our sample to firms that were 20 years or younger at the time of the IPO. As a result, 7% of IPO firms, which are predominantly pure private equity transactions that do not conform to the notion of entrepreneurship, are dropped from the sample. While noisier, our results are robust to the inclusion of such firms. As a robustness check, we also examine a conservative sample of firms that were 15 years or younger at the time of the IPO, reducing the sample by 4%. All results remain qualitatively similar.

Finally, we obtain a list of 319 entrepreneurial ventures, of which 99 (31.03%) are CVC funded. This proportion of CVC-funded ventures is largely consistent with the value found in prior studies examining CVC-backed IPO firms (Chemmanur et al. 2014). However, we note that it is greater than the proportions reported in other CVC studies (4%–8%) that have considered the entire population of U.S. firms receiving VC financing (e.g., Dushnitsky and Shaver 2009). The stark difference stems from the fact that our study uses a sample of ventures that eventually go public, thereby excluding seed-stage ventures. Therefore, within this subpopulation of relatively later-stage "successful" firms, the proportion of CVC-funded ventures is naturally higher than the proportion within the entire population. Although the IPO sample allows us to control for a wide range of firm characteristics, it may be subject to sample selection problems because, compared with IVC firms, CVC firms may invest in more R&D-intensive and, in turn, successful ventures. We will discuss this issue in more detail below. Throughout our analyses, the unit of analysis is the venture.

Measures

Dependent Variable. Our dependent variable (DV) is *R&D intensity*, which is taken from the last year that the venture was a private firm before eventually going public and is measured as the ratio of R&D expenditures to total assets.[10] Our sample includes young ventures, which often have very low and unstable sales. Their inclusion may lead to biased R&D intensity normalized by sales, as some companies may have high R&D intensity because of their limited sales rather than because of their extensive R&D investment. Hence, although R&D intensity normalized by sales is a relatively accurate measure for established firms, it is not an accurate variable for young entrepreneurial ventures. By contrast, the total assets of young entrepreneurial ventures are relatively stable and thus serve as a reasonable measure of firm size. Thus, we normalize R&D expenditures by firm assets to measure the relative intensity of firms' R&D investment and adjust for firm size. Other studies also standardize R&D investment by total assets because firms often do not have sales in the early years of product development (e.g., Kor 2006). While we report all of our main results using this measure, following prior studies (e.g., Baysinger et al. 1991), we also use an alternative measure, R&D investment per employee, to perform a robustness check. The results are qualitatively similar.

Independent Variables. For *CVC ownership*, we measure the proportion of shares held by CVC firms, which is calculated as the percentage of the total number of the venture's shares. The information on principal stockholders in Form S-1 reflects the composition of investors who substantially influence a firm's strategy

because it includes investors who retain their shares when the venture goes public. Consistent with prior CVC studies (e.g., Dushnitsky and Shaver 2009, Park and Steensma 2012), we exclude diversified banks and insurance companies because the resources that they provide do not directly relate to the technology commercialization or R&D of new ventures.

Founder incumbency takes a value of 1 if the founder is a CEO or a technology-related executive, such as a CTO or chief scientist, and 0 otherwise. In cases with more than one founder, we label the venture as having a founder as an incumbent manager if any of the cofounders is a CEO or a technology-related executive. In our context, we need to consider not only the CEO but also significant executives, such as the CTO, when investigating the effect of founder incumbency on a venture's R&D intensity. In our sample, the founder is the CEO in 141 ventures and the CTO in 52 ventures, and the founder is not present at the time of IPO in 126 ventures.

Control Variables. We control for additional factors that may affect *R&D intensity*, such as factors pertaining to other shareholders' shares, venture characteristics, and pre-IPO financing processes. As discussed previously, different types of investors may have heterogeneous preferences regarding R&D investment (Hoskisson et al. 2002, Kim et al. 2008). The influence of CVC ownership on R&D investment may vary according to the relative proportion of shares owned by other types of shareholders. Therefore, we control for other shareholders' effects by including *founder ownership* and *VC ownership*, which are calculated as the percentages of the total number of shares of the entrepreneurial firm that founders and VC firms own, respectively.[11]

Prior studies also find that financial slack affects R&D investment (e.g., Kim et al. 2008, Nohria and Gulati 1996). Following previous studies, we calculate *financial slack* as the natural log of cash and cash equivalents and include it as a control variable. In addition, we control for *venture age* at the time of the IPO (Kim et al. 2008) because entrepreneurial ventures may use their financial resources for purposes other than R&D (e.g., marketing expenses) as they become more mature. Corporate governance status may also affect firms' R&D investment. Prior studies (e.g., Kor 2006) find that CEO–chairman duality and board member composition (insider versus outsider) affect firm R&D investment. To control for these effects, we include the *number of inside board members*, *number of outside board members*, and *CEO–chairman duality*, which take the value 1 if the CEO is also the chairman and 0 otherwise.

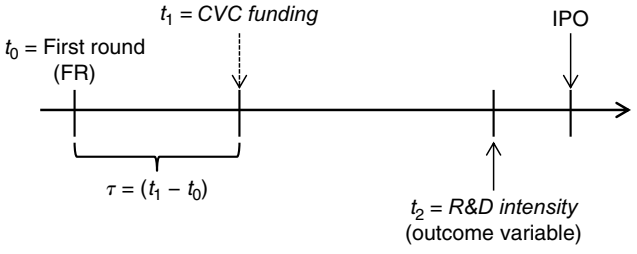
The pre-IPO financing processes that a start-up has undergone may reflect venture characteristics that also affect R&D investment. For example, ventures that require particularly extensive R&D investment may pursue more external financing rounds (e.g., higher burn rate), pursue more investors (i.e., tap into a variety of investor sources), and, accordingly, raise more funds. We control for the *number of fundraising rounds*, the natural log of the *total amount invested* (i.e., the total amount of funding that a focal venture received from IVC/CVC firms and other investors prior to an IPO), and the *total number of investors* (i.e., the total number of investors backing the focal venture). We also include state and industry fixed effects in our regressions.[12] All standard errors are clustered at the level of the lead investing firm (i.e., 195 lead investors).

Analytical Approach

Selection Bias. To test our hypotheses, we first examine how *CVC ownership* and *founder incumbency* are related to an entrepreneurial venture's *R&D intensity* by using ordinary least squares (OLS) regressions. However, the recent CVC literature (Park and Steensma 2013) suggests that CVC-funded ventures may be systematically different from IVC-only-funded ventures, potentially leading to selection bias; that is, rather than CVC firms leading ventures to become more R&D intensive, as we hypothesize in H1, CVC-funded ventures may merely be a selection of more R&D-intensive firms relative to IVC-only-funded ventures because CVC firms expect those selected ventures to be more advantageous to the CVC firm's parent company's core business (Dushnitsky and Lenox 2006). However, in contrast to prior studies, we conjecture that our sample selection scheme significantly reduces such endogeneity concerns because our sample consists of ventures that eventually go public, representing a relatively homogenous sample of successful and perhaps more R&D-intensive firms compared with the entire population of entrepreneurial ventures. In other words, even the IVC-only-funded ventures in our sample are a selection of successful, and perhaps R&D-intensive, ventures. Nonetheless, we run a selection model (Heckman 1979) along with our main outcome model (OLS) in a two-stage estimation procedure to address such endogeneity due to selection bias (Hamilton and Nickerson 2003) and to test the validity of our conjecture about our sample selection scheme.

Figure 1 shows the timeline of the relevant variables used in our two-stage estimation procedure. All ventures enter the database once they receive a first round

Figure 1. Timeline of Relevant Variables Used in the Two-Stage Selection Model



of venture capital funding from an external investor. Furthermore, some are funded by a CVC at t_1, whereas others are not. We then capture our outcome variable, *R&D intensity*, at t_2, which is the last year in which the venture was private before eventually going public at t_3. Our first-stage selection model estimates the propensity for new ventures to receive CVC funding given the initial venture characteristics at t_0. In addition, this selection model should exploit at least one exogenous variation that is not part of the second-stage outcome model. In our case, we follow the approach used in prior CVC studies (e.g., Alvarez-Garrido and Dushnitsky 2016, Park and Steensma 2012) and use the aggregate *availability of CVC* funds. Similar to Brander et al. (2015), we assume that the aggregate *availability of CVC* funds is exogenous to the focal venture's characteristics; that is, we use the total dollar amount of CVC investment in a given year, which aggregates all CVC investment dollars made by all CVC firms that are active in the focal year. This measure reflects the total amount of money available for investment purposes at the industry level. The identification assumption here is that changes in the *availability of CVC* funds in a particular industry affect innovation in firms only through the probability that they secure CVC funding. The main limitation is that changes in the *availability of CVC* funds may be correlated to concomitant changes in firms' innovation opportunities (Bertrand and Mullainathan 2003). As in prior CVC studies (e.g., Alvarez-Garrido and Dushnitsky 2016, Park and Steensma 2012), we expect a new venture to be more (less) likely to be funded by a CVC firm when the *availability of CVC* funds is high (low) (Brander et al. 2015, Paik and Woo 2014). We capture this measure at t_1, i.e., the time of actual CVC funding, for CVC-funded firms. Because we cannot observe t_1 for IVC-only-funded firms, we take the average lag between the first round of funding and actual CVC funding, i.e., $\tau = (t_1 - t_0)$, from the subset of CVC-funded ventures and use $t_1' = t_0 + \tau$ for IVC-only-funded ventures to determine the timing of the *availability of CVC* funds. In our sample, $\tau = 2.3$ years. In addition, we assume that our measure of the *availability of CVC* at t_1 is not correlated with the innovation opportunities that the focal venture has at time t_2, when we observe its *R&D intensity*. Given that the time between t_1 and t_2 is approximately four to five years in our data, this identification assumption may be reasonable. The data on CVC fund availability are obtained from the National Venture Capital Association (NVCA) and are measured annually. Therefore, we use a two-year lag in our regressions. As a robustness check, we also use a three-year lag, and the results are fully robust to this alternative specification. The NVCA data only start in 1995. Thus, we lose seven observations (2.2%) because of missing data when we run the selection model.

From the first-stage selection equation, we compute the inverse Mills ratio (λ: *Lambda*), which is used to correct for any selection bias in the second-stage outcome equation (Wooldridge 2002). Hence, our two-stage procedure takes the following functional form:

$$\text{Prob}(CVC = 1) = \Phi(Z\gamma_1), \quad \text{[selection equation]}$$

$$E(y \mid CVC = 1) = X'\beta + \rho\sigma\hat{\lambda}(Z\gamma_1), \quad \text{[outcome equation]}$$

$$\hat{\lambda}(Z\gamma_1) = \frac{\phi(Z\hat{\gamma}_1)}{\Phi(Z\hat{\gamma}_1),} \quad \text{[inverse Mills ratio]}$$

where, in the first-stage selection equation, $CVC = 1$ indicates whether a new venture receives CVC funding, and Z is a set of explanatory variables, including the *availability of CVC*, and initial venture characteristics at t_0, such as the *total number of investors*, the *total amount invested* in the venture, the *venture age*, and a series of dummies for a company's stage of development (i.e., *seed/start-up/early stage/expansion/later stage*). We also include a dummy variable, *founder present*, to indicate whether the founder was present at the time of CVC funding. In the second-stage outcome equation, y denotes the dependent variable, *R&D intensity*, and X is a set of explanatory variables, including our potential endogenous variable due to selection bias, *CVC ownership*. The term $\hat{\lambda}$ is the inverse Mills ratio computed from the first stage.

Reverse Causality. In addition to the selection bias noted above, reverse causality may be a concern (e.g., Singh and Mitchell 2005); that is, a CVC firm's ownership of a new venture at the time of the IPO may be affected by the venture's greater R&D intensity rather than vice versa. If the venture invests in R&D in a sustained manner, the CVC investor may retain more ownership of the venture. By contrast, if the venture does not sufficiently invest in R&D, the CVC investor may reduce its investment or even withdraw its investment altogether (overestimation of *CVC ownership*). Alternatively, if ventures that invest more in R&D raise more VC funding rather than additional CVC funding, then CVC ownership can decrease due to dilution (underestimation of *CVC ownership*). If we do not consider these reverse causalities, then our CVC ownership effect may be systematically biased.

We address this problem by performing a two-stage least squares (2SLS) regression analysis with an instrumental variable (IV; Wooldridge 2002). We use the predicted values from the first stage as instruments for the endogenous variable in the second stage (Angrist 2001, Angrist and Pischke 2008). In the first stage, we predict retained CVC ownership at the time of a venture's IPO with an instrumental variable, *CVC fund size*, which is a CVC firm-specific measure that is captured at time t_2 (see Figure 1) and that differs substantially across corporate investors. This variable measures the total dollar amount of financial resources that an incumbent

corporation has committed to the CVC program for investment purposes. For example, while their annual revenues are comparable (approximately $45 billion at the end of 2015), Pfizer allocates an annual budget of $50 million to CVC activity, while Merck and Novartis allocate $250 million and $600 million, respectively, to CVC activity. The key identifying assumption is that the size of the incumbent corporation's CVC program in itself does not directly affect the investee venture's R&D intensity; rather, it affects it only through their retained ownership in the investee venture.

Just as IVC firms invest in portfolio companies with limited available resources, CVC investment managers invest in portfolio companies using the resources committed by the corporate parent. However, in contrast to the resources available to IVC firms, which raise funds from limited partners, those available to CVC firms are primarily determined by an administrative process that occurs at the parent corporation (Dushnitsky and Shapira 2010). This (bureaucratic) process differs substantially across CVC programs and is largely independent of potential investee venture characteristics (Chesbrough 2002, Macmillan et al. 2008). When CVC programs are large, CVC investment managers have a greater ability to invest, increase their investment in a focal venture, and retain their shares in ventures in which they have invested for a longer period. By contrast, when CVC programs are small, CVC investment managers tightly manage their investment in portfolio companies, liquidate their investment relatively early, and then invest in new deals. Our interviews with CVC managers confirm such CVC investment behavior. Thus, the size of the fund that a focal CVC firm manages is positively associated with CVC retained ownership at the time of a given venture's IPO. However, the instrument's effect on the focal venture's R&D intensity occurs *only through* the variable that is instrumented, the venture's *CVC ownership* (i.e., exclusion restriction; Angrist et al. 1996). In the weak instrument test, the *F*-statistic of the instrumental variable is 16.704, which is significantly larger than 10, the threshold recommended in the econometrics literature (e.g., Staiger and Stock 1997, Stock and Yogo 2005, Stock et al. 2002). This result provides additional support for the validity and strength of our instrumental variable. However, as is often the case with exclusion restrictions, we recognize that it may be possible to produce a rationale as to why the instrument could directly affect the outcome variable in another way (e.g., the *CVC fund size* may correlate with unobserved qualities of the founders). We acknowledge that we cannot fully exclude the possibility of unobserved heterogeneity across ventures; thus, we note that further research based on quasi-natural experiments would allow for an even cleaner identification.

Propensity Score Matching. *Founder incumbency* is not randomly assigned across firms; rather, it may be affected by a variety of firm characteristics. Thus, we use a propensity score matching (PSM) method to mitigate such endogeneity problems when testing H2. PSM allows us to minimize the differences in observable characteristics between firms that retain their founders and those that do not. While matching cannot control for unobservable differences, PSM creates a matched sample of treatment and control observations that are similar with respect to observable characteristics, except for the treatment (*founder incumbency* = 1; Angrist and Pischke 2008, Dehejia and Wahba 2002). In our study, we use firms with founder managers as the treatment group (N = 193) and create a matched sample from our control group (*founder incumbency* = 0) using the propensity scores estimated by a probit model based on our set of control variables as our matching dimensions. We use a nearest-neighbor matching implementation within a common support, with replacement, of the PSM approach originally developed by Rosenbaum and Rubin (1983). As a robustness check, we perform the matching based on a variety of criteria, such as radius, kernel density, stratification, and bootstrapping standard errors, and they all produce qualitatively equivalent results.

Results

Main Results

Table 2 presents descriptive statistics and pairwise correlations for our variables. Although we do not report variance inflation factors (VIFs) separately, we compute them to identify any multicollinearity concerns in our regression analyses. All the VIF values are below 3, which is significantly below the suggested cutoff value, indicating that multicollinearity is not a problem in our study (Kennedy 2003).

Models (1)–(4) in Table 3 present OLS regressions to provide some baseline results. As shown, both *CVC ownership* and *founder incumbency* are positively associated with *R&D intensity* and are statistically significant. Thus, the baseline results of the OLS regressions are consistent with both H1 and H2. However, as discussed, *CVC ownership* may be endogenous, and the OLS regression results may be biased due to selection bias and reverse causality. Hence, we use OLS results only as a benchmark for comparison with our two-stage selection model and 2SLS estimation results.

Model (5) in Table 3 addresses the potential selection bias issue discussed earlier using a two-stage selection model to test H1; that is, we test whether CVC-funded ventures began as more R&D-intensive ventures than IVC-only-funded ventures within our sample. The model reports the second-stage outcome equation, in which we correct for selection bias by including the inverse Mills ratio ($\hat{\lambda}$: *Lambda*) calculated

Table 2. Summary Statistics and Pairwise Correlation Matrix for All Variables

Variables	Mean	Median	S.D.	Min	Max	(1)	(2)	(3)	(4)	(5)
(1) *R&D intensity*	0.240	0.155	0.264	0.00	2.29	1.000				
(2) *CVC ownership*	0.045	0	0.087	0.00	0.57	0.192*	1.000			
(3) *Founder incumbency*	0.605	1	0.490	0.00	1.00	0.188*	0.009	1.000		
(4) *Founder ownership*	0.107	0.046	0.161	0.00	0.99	−0.041	−0.055	0.312*	1.000	
(5) *VC ownership*	0.495	0.511	0.258	0.00	1.00	−0.026	−0.241*	−0.139*	−0.405*	1.000
(6) *Financial slack*	4.054	4.051	1.563	0.51	11.74	−0.227*	0.078	−0.002	0.127*	−0.024
(7) *Venture age*	8.088	7	3.588	2.00	20.00	−0.198*	0.026	−0.258*	0.080	−0.143*
(8) *Number of inside board members*	1.367	1	0.640	0.00	5.00	−0.076	−0.060	0.263*	0.273*	−0.122*
(9) *Number of outside board members*	5.727	6	1.561	1.00	12.00	0.087	0.095	−0.055	−0.176*	0.075
(10) *CEO–chairman duality*	0.411	0	0.493	0.00	1.00	−0.148*	−0.061	0.140*	0.184*	−0.170*
(11) *Number of fundraising rounds*	5.972	6	2.939	1.00	15.00	0.222*	0.081	0.003	−0.203*	0.121*
(12) *Total amount invested*	11.257	11.291	1.103	4.94	15.35	0.085	0.163*	−0.051	−0.292*	0.110*
(13) *Total number of investors*	9.790	9	5.833	1.00	31.00	0.226*	0.164*	0.004	−0.321*	−0.001
(14) *Availability of CVC* ($M)	4,476.220	2,619.180	4,236.578	470.33	15,196.72	−0.100	−0.006	−0.118*	−0.066	0.004
(15) *CVC fund size* ($M)	1.156	0	3.819	0.00	35.83	0.009	0.348*	0.075	0.000	−0.132*

Variables (Continued)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(6) *Financial slack*	1.000								
(7) *Venture age*	0.003	1.000							
(8) *Number of inside board members*	−0.016	−0.059	1.000						
(9) *Number of outside board members*	0.053	−0.034	−0.284*	1.000					
(10) *CEO–chairman duality*	−0.018	0.056	0.179*	−0.132*	1.000				
(11) *Number of fundraising round*	−0.004	0.027	−0.112*	0.307*	−0.157*	1.000			
(12) *Total amount invested*	0.172*	−0.090	−0.152*	0.409*	−0.184*	0.484*	1.000		
(13) *Total number of investors*	0.039	0.022	−0.182*	0.345*	−0.154*	0.617*	0.435*	1.000	
(14) *Availability of CVC* ($M)	−0.029	0.199*	−0.033	−0.024	0.199*	0.018	−0.052	0.171*	1.000
(15) *CVC fund size* ($M)	0.254*	−0.025	−0.086	0.024	0.029	0.139*	0.196*	0.262*	−0.018

Notes. $N = 319$.
*Significant at the 5% level or higher.

from the first stage. Table A1 in the online appendix reports the first-stage estimation results (i.e., selection equation). Consistent with our OLS results, *CVC ownership* remains positively associated with *R&D intensity* at the 1% significance level, even after we correct for selection bias. In addition, $\hat{\lambda}$ is not statistically significant ($p = 0.44$), and a Wald test shows that the coefficients for *CVC ownership* in models (4) and (5) (0.4475 versus 0.4661) are not significantly different (Shaver 1998). Therefore, as previously conjectured, *conditional* on going public, selection bias does not appear to be a concern in our sample.

Models (6) and (7) in Table 3 report the first and second stages of the 2SLS estimation results, respectively, which address reverse causality to test H1; that is, we attempt to tease out whether greater CVC ownership leads entrepreneurial ventures to invest more in R&D, as we hypothesize, or whether more R&D-intensive ventures lead CVC firms to retain greater ownership. In practice, the relationship may operate in both directions. Nonetheless, our 2SLS approach can mitigate such reverse causality concerns. Our instrument, *CVC fund size*, is positive and statistically significant at the 1% level in the first stage, suggesting that the instrument is statistically valid. In the second stage, both *CVC ownership* and *founder incumbency* remain positive and statistically significant, even after we mitigate the reverse causality concerns. However, the magnitude of the coefficient for *CVC ownership* is increased to a certain degree because more R&D-intensive ventures are able to raise additional VC financing in later rounds. Thus, because of dilution, CVC ownership (percentage) in R&D-intensive ventures can decrease at the time of the IPO.

Overall, the results in Table 3 strongly support H1. Because our 2SLS approach mitigates the reverse causality concerns (and selection bias is unlikely to be present), we compute the marginal effects by using the results from model (7) at the mean value of our explanatory variables. According to model (7), for every 1% increase in *CVC ownership* relative to the omitted shareholder group of a focal venture, the venture increases its *R&D intensity* by approximately 0.76%. Thus, our results are not only statistically significant but also economically significant—and realistic.

Table 4 reports our PSM analysis that supports H2. The total sample size is reduced ($N = 193 + 66 = 259$) because we consider only observations within the common support where the balancing property is satisfied after matching. After matching, the only major difference between the two groups is whether the founder

Table 3. CVC Ownership, Founder Incumbency, and R&D Intensity of IPO Firms: Main Results

DV: *R&D intensity*	OLS				Selection	IV–2SLS	
Variables	(1)	(2)	(3)	(4)	(5) 2nd stage	(6) 1st stage	(7) 2nd stage
Founder ownership	0.1220	0.1570*	0.0488	0.0847	0.2245	−0.0810***	0.1102
	(0.0857)	(0.0867)	(0.0880)	(0.0887)	(0.1446)	(0.0311)	(0.0907)
VC ownership	−0.0186	0.0260	−0.0154	0.0284	−0.0460	−0.0860***	0.0594
	(0.0559)	(0.0557)	(0.0541)	(0.0541)	(0.0704)	(0.0201)	(0.0627)
Financial slack	−0.0331***	−0.0355***	−0.0320***	−0.0343***	−0.0471***	0.0165***	−0.0360***
	(0.0126)	(0.0126)	(0.0122)	(0.0123)	(0.0106)	(0.0049)	(0.0125)
Venture age	−0.0110***	−0.0111***	−0.0082***	−0.0083***	−0.0111**	0.0014	−0.0085***
	(0.0028)	(0.0030)	(0.0028)	(0.0030)	(0.0048)	(0.0018)	(0.0032)
Number of inside board members	−0.0261	−0.0257	−0.0355*	−0.0349	−0.0424	0.0047	−0.0345*
	(0.0202)	(0.0201)	(0.0213)	(0.0212)	(0.0284)	(0.0064)	(0.0205)
Number of outside board members	−0.0034	−0.0031	−0.0035	−0.0032	−0.0056	0.0019	−0.0030
	(0.0097)	(0.0095)	(0.0097)	(0.0095)	(0.0101)	(0.0038)	(0.0093)
CEO–chairman duality	−0.0218	−0.0193	−0.0305	−0.0279	0.0060	−0.0036	−0.0260
	(0.0247)	(0.0240)	(0.0240)	(0.0233)	(0.0330)	(0.0103)	(0.0227)
Number of fundraising rounds	0.0124	0.0132	0.0121	0.0128	0.0168**	−0.0022	0.0133
	(0.0092)	(0.0091)	(0.0089)	(0.0088)	(0.0073)	(0.0023)	(0.0085)
Total amount invested	−0.0136	−0.0176	−0.0136	−0.0175	−0.0172	0.0114**	−0.0203*
	(0.0125)	(0.0121)	(0.0124)	(0.0121)	(0.0247)	(0.0047)	(0.0121)
Total number of investors	0.0044	0.0039	0.0036	0.0031	0.0025	−0.0007	0.0027
	(0.0029)	(0.0029)	(0.0029)	(0.0030)	(0.0036)	(0.0011)	(0.0030)
CVC ownership		0.4554***		0.4475***	0.4661***		0.7644*
		(0.1362)		(0.1328)	(0.1574)		(0.3976)
Founder incumbency			0.0769**	0.0753**	0.0633*	−0.0045	0.0742**
			(0.0308)	(0.0306)	(0.0337)	(0.0094)	(0.0295)
Lambda ($\hat{\lambda}$)					−0.0481		
					(0.0629)		
CVC fund size ($M)						0.0076***	
						(0.0022)	
Constant	0.5442***	0.5446***	0.5127***	0.5138***	0.6526***	−0.0037	0.5147***
	(0.1861)	(0.1835)	(0.1810)	(0.1784)	(0.2511)	(0.0532)	(0.1727)
State dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	319	319	319	319	312	319	319
F-stat./Wald chi-squared	7.39***	8.37***	6.93***	7.91***	132.36***	16.70***	164.61***
R-squared	0.3279	0.3465	0.3431	0.3610		0.2731	0.3520

Note. Heteroskedasticity-robust standard errors clustered at the lead investor level are presented in parentheses.
*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

is an incumbent manager. According to Table 4, the *average treatment effect on the treated* (*ATT*) is positive and statistically significant at the 5% level, which suggests that having a founder CEO or founder CTO may increase the R&D intensity of the focal venture by 8.4% relative to that of a venture that does not have a founder in such a position.[13] Note, however, that our result can still be vulnerable to selection on *unobservable* characteristics because one common pitfall of PSM is that matching is based only on observable characteristics.

Table 5 reports results that test H3. H3 proposed that the relationship between CVC ownership and an entrepreneurial venture's R&D intensity is stronger when the founder is an incumbent top manager. In Table 5, we show a split sample analysis based on whether a firm's founder is an incumbent top manager. For the sake of brevity, we report only the second-stage results from our 2SLS regressions. In both models, *CVC ownership* is positive and statistically significant, and a Wald test comparing the two coefficients across the models

Table 4. Testing H2 Using Propensity Score Matching

Treatment group	(Matched) control group	*ATT*	*t*-stat.
Founder incumbency = 1	*Founder incumbency* = 0	0.084**	2.490
(*N* = 193)	(*N* = 66)	(0.036)	

Notes. The standard error for *ATT* is reported in the parentheses. The numbers of treated and controls refer to actual nearest neighbor matches, with replacement, within the common support. The balancing property is satisfied.
**$p < 0.05$

Table 5. Testing H3 Using Split-Sample Analysis (2SLS)

DV: *R&D intensity* Variables	(1) H3: *Founder incumbency* = 1	(2) H3: *Founder incumbency* = 0
CVC ownership	1.3431**	0.3441*
	(0.6398)	(0.2130)
Controls	Yes	Yes
State dummies	Yes	Yes
Industry dummies	Yes	Yes
Observations	193	126
F-stat./Wald chi-squared	98.99***	97.90***
R-squared	0.3396	0.4574

Notes. Heteroskedasticity-robust standard errors clustered at the lead investor level are presented in parentheses. The Wald test shows that the differences between the two coefficients across models (1) and (2) are statistically significant ($t = 16.855$).
*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

shows that the two coefficients are significantly different (p-value = 0.00).[14] Therefore, the CVC ownership effect is greater when the founder is an incumbent top manager, lending support for the knowledge spillover mechanism hypothesized in H3. According to models (1) and (2) in Table 5, for every 1% increase in the CVC ownership relative to the omitted shareholder group of a focal venture, the venture increases its R&D intensity by approximately 1.34% when the founder is an incumbent manager and by 0.34% when she is not.

Robustness Checks

We conduct a number of robustness checks to gain more confidence in our main results before moving to our auxiliary results in the next section, which investigate our hypothesized mechanisms. To check the robustness, we use a host of alternative model specifications, including (1) the use of a dummy variable for CVC-funded ventures instead of the continuous *CVC ownership* variable, (2) the use of the logarithm of one plus R&D spending as the dependent variable and the addition of the logarithm of total firm assets on the right-hand side of the model as a control, (3) the exclusion of all observations with *R&D intensity* equal to zero ($n = 7$), (4) the use of a Tobit model that treats all observations with an *R&D intensity* equal to zero as censored data, (5) the exclusion of an outlier (*R&D intensity* = 2.29), and (6) the use of normalized *R&D intensity* as the dependent variable. All results continue to support our hypotheses. Tables A2–A6 in the online appendix report these results.

Next, we consider whether the founder incumbency effect that we identified in H2 is mainly driven by founders with strong technological backgrounds, which are common in technology-intensive industries. If, systematically, founders have strong technological backgrounds but professional agent managers do not, and this difference in background enables founder managers to invest more in R&D, then the founder effect that we identified could be attributable to a strong *technological background effect* rather than to an *entrepreneurial founder effect* per se. Hence, we examine whether the founder effect robustly holds for founders with nontechnical backgrounds (e.g., marketing or finance). To do so, we collect data on founders' backgrounds and classify founders as having a strong technological background if they obtained a Ph.D. in science or engineering (32.9% of our sample). Adding this variable as a control and rerunning models (6) and (7) in Table 3 yields results that are similar to our main results (*founder incumbency* has a coefficient of 0.0737 and is statistically significant at the 5% level). Thus, our founder effect holds even for founders with nontechnical backgrounds, suggesting that entrepreneurial spirit and stronger attachment to the firm are important distinguishing traits of founder managers, as hypothesized in H2. Table A7 in the online appendix reports these results.

Auxiliary Results: Mechanisms

Our hypothesized mechanisms may need further support, especially to understand H3. If our instrument, *CVC fund size*, violates the exclusion restriction, there could be alternative explanations beyond the knowledge spillover mechanism that we hypothesized in H3. In particular, the positive interaction effect between *CVC ownership* and *founder incumbency* may not reflect a knowledge spillover mechanism; instead, it may simply be a consequence of a positive selection. For example, founder managers who might tend to spend more on R&D could be attracting more CVC investment than professional managers do. However, our data indicate that the average patent count at the time of CVC funding does not differ significantly based on whether the founder was present (p-value = 0.79). This finding suggests that ventures with founder managers are not more likely to attract CVC investment than ventures with professional agent managers. Therefore, this result somewhat mitigates the endogeneity concern stemming from positive selection, although it does not completely eliminate it. In the following section, we present various supporting results to tease out some of our key mechanisms, with a particular emphasis on identifying the hypothesized knowledge spillover mechanism.

Industry Heterogeneity. Some of the hypothesized mechanisms might differ according to industry characteristics. For example, while the tension that arises between CVC and IVC investors may exist universally across all industries, the relative severity may differ. Thus, the magnitude of the positive CVC ownership effect on a venture's R&D intensity may differ as well. In the ICT sector, the positive CVC ownership effect should be smaller in magnitude relative to that in the BT sector because, as the venture approaches an IPO,

resources are more likely to be allocated to non-R&D activities such as marketing (e.g., user acquisition or promotion). Consistent with this view, Table A8 in the online appendix shows that the coefficient of *CVC ownership* in the ICT sector is indeed smaller in magnitude relative to that in the BT sector (p-value = 0.00). The result suggests that the level of IVC–CVC investor conflict differs across industries. These results are consistent with a recent study that suggests that CVC investments are used in the BT sector as a way of identifying early-stage technologies that are later acquired either through an acquisition or a license agreement (Ceccagnoli et al. 2015).

Next, the effect of the CVC investor–founder interaction and the knowledge spillover mechanism hypothesized in H3 can also be different across industries.[15] In Table A9 in the online appendix, we explore this possibility by splitting our sample based on sectors and observe the magnitude of the interaction effect across sectors. Our results show that having a founder manager increases the positive CVC ownership effect on R&D intensity by 43% in the ICT sector and by 39% in the BT sector. Thus, there could seemingly be (marginally) more knowledge spillover during the CVC investor–founder interaction in the ICT sector compared with the BT sector.

CVC Investor Heterogeneity. Not all CVC investors are the same. Some CVC programs are tightly integrated with the corporate parent and are more strategic investors. In such cases, CVC programs provide active interaction, and knowledge spillover is more likely to occur. Other CVC programs are more standalone financial investors. In these cases, CVC investments are made to mitigate uncertainty, and spillovers are less likely to occur. Thus, we examine each CVC firm's mission statement to observe how it describes its investment objectives and whether it emphasizes a tight relationship with its corporate parent. In addition, we investigate whether the CVC firm's physical address is identical to that of the corporate parent's headquarters. We also check whether the head of the CVC program simultaneously holds a senior position in the corporate parent because, if so, she will interact closely with executives of the corporate parent and investee ventures. Furthermore, for cases in which the CVC investor holds a seat on the venture's board, we examine how the proxy statement describes the board member (i.e., whether she is an executive in the corporate parent). Therefore, using these criteria, the level of a CVC firm's integration with its corporate parent is measured using a binary indicator that is equal to 1 if the CVC program is not an independent wholly owned subsidiary, legally or practically (*cvc_integrated* = 1/0). In addition, for cases in which the CVC investor holds a seat on the venture's board, we use a separate binary indicator (*cvc_board* = 1/0). With these additional data, we tease out some of our hypothesized mechanisms.

First, results in Table A10 in the online appendix show that, among CVC-funded ventures (regardless of founder incumbency), ventures that have a CVC investor on the venture's board exhibit greater R&D intensity than those that do not (p-value = 0.00). The result supports one of the key mechanisms hypothesized in H1, namely, the *direct corporate governance effect*. In other words, CVC investors can have a positive effect on the investee venture's R&D investment strategy, especially when they sit on the venture's board.

Second, results in Table A11 in the online appendix show that, among CVC-funded ventures with founder managers, ventures funded by *tightly integrated* CVC programs display greater R&D intensity than those that are funded by more standalone CVC programs (p-value = 0.00). The result suggests that founders utilize more knowledge spillover when they interact with *tightly integrated* CVC programs compared with more standalone CVC programs. This finding is consistent with the knowledge spillover mechanism hypothesized in H3.

Third, while our main results show that the positive effect of CVC ownership on R&D intensity is greater when the venture is managed by founders, in general, our results in Table A12 in the online appendix show that having a CVC investor on the venture's board does not make any significant difference in the CVC investor–founder interaction effect (p-value = 0.64); that is, CVC-funded ventures' R&D intensities are equally high when founders manage the venture, regardless of whether a CVC investor sits on the venture's board. The result implies that there are indeed various sources of knowledge spillover beyond top managers' interactions with CVC investors during board meetings, supporting the hypothesized mechanism in H3.

Last, panels A and B in Table A13 in the online appendix show that the CVC investor–founder interaction effect becomes stronger if the founder has a strong technological background than if the founder does not. Panel B replicates panel A, but as a robustness check, it adds another control variable for the venture's absorptive capacity (AC). As shown, the results are qualitatively similar in both panels. Following Veugelers (1997), we measure the AC of the venture company with an indicator variable, *venture AC*, which is equal to 1 if the venture hired at least one employee—other than the founder or top manager—with a Ph.D. in science or engineering. In both panels A and B, the Wald test shows that the differences between the two coefficients across models (1) and (2) are statistically significant (p-value = 0.00 in both cases); thus, strong technological background matters. We also find that CVC-funded ventures with founder managers who do not have strong technological backgrounds display greater R&D intensity than CVC-funded ventures with professional agent managers who do not have strong technological

backgrounds. In both panels A and B, the Wald test shows that the differences between the two coefficients across models (2) and (4) are statistically significant (p-value = 0.06 and p-value = 0.01, respectively); thus, strong entrepreneurial spirit matters. Therefore, these results are consistent with the mechanisms hypothesized in H2 and H3 and suggest that founders can utilize knowledge spillover more effectively if they have a strong technological background. At the same time, both technological and nontechnological knowledge are involved in the CVC investor–founder interaction.

Taken together, these results suggest that, while the *direct corporate governance effect* of the CVC investing firm is salient if the CVC investor has a seat on the venture's board (regardless of founder incumbency), *knowledge spillover*, which founders more effectively utilize than professional managers, likely occurs through channels other than interactions with CVC investors during board meetings. For example, as hypothesized in H3, these channels include formal/informal conversations with suppliers, buyers, or key employees of the CVC firm's parent company or interactions with other key industry players that the CVC investor introduces to the portfolio company. Some other channels include interactions at CVC-sponsored annual meetings or start-up assistance programs. During such meaningful contact, entrepreneurial founders can identify more investment opportunities than professional managers can. Our interviews with CVC investors and founders revealed ample anecdotal evidence consistent with these hypothesized mechanisms.

Extensions

We provide important extensions of our main findings to protect us from any potential weaknesses in our research design and to add some substantive insights.

CVC Ownership Effect in Non-IPO Ventures. In our study, we used a sample of ventures that eventually went public because our outcome of interest, firm *R&D intensity*, and other key firm characteristics are publicly available only when the venture goes public. In addition, at the time of an IPO, CVC–IVC investor tension is at its strongest, and *founder incumbency* varies to some degree across ventures. However, because CVC-backed ventures that eventually go public may systematically differ from CVC-backed ventures that choose not to go public, we attempt to avoid potential sample selection bias that may stem from analyzing a sample that includes only ventures that eventually go public. In other words, we further empirically investigate whether our main findings similarly apply to *privately held* ventures that could have gone public but did not. Obviously, some of the hypothesized mechanisms can be softened for non-IPO firms (e.g., the CVC–IVC investor tension that arises upon reaching an IPO will be lacking).

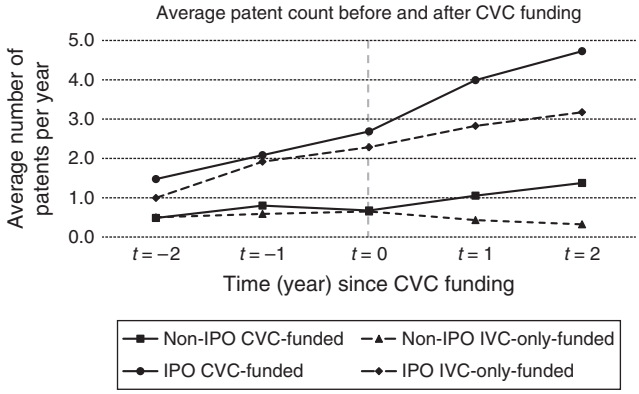
We note that, when examining privately held ventures, many data restrictions prevent us from fully replicating the analysis performed above. We are unable to observe *R&D intensity* (or many internal firm characteristics) if a firm does not go public. Therefore, we use patent counts, a commonly used measure of R&D outcome (i.e., innovation output) in previous CVC studies (e.g., Alvarez-Garrido and Dushnitsky 2013, Chemmanur et al. 2014), as our dependent variable because it has a strong positive association with R&D expenditure (Hausman et al. 1984). We then examine whether CVC-funded, privately held ventures tend to generate more R&D output ex post CVC funding (which should be consistent with more R&D investment) compared with IVC-only-funded, privately held ventures using a difference-in-differences framework (with $\tau = 2.3$ years from Figure 1). We first create a one-to-one matching sample of non-IPO ventures from VentureXpert based on a number of observable venture characteristics, including *CVC funding year*, *venture development stage at CVC funding*, *founding year*, *state*, *industry*, *first funding year*, and *venture development stage at first funding year*, to replicate our original sample as closely as possible. Thus, we construct a sample of 319 non-IPO, privately held ventures that are nearly "identical" to our original sample and that could have gone public but did not. We then collect annual patent data on these ventures.

Because our sample is matched, we report only the trend in R&D output in Figure 2. As shown, R&D output increases after CVC funding for both samples (IPO and non-IPO ventures), and the gap in patent counts between CVC-funded ventures and IVC-only-funded ventures increases after CVC funding as well. These results are consistent with those of prior studies (e.g., Alvarez-Garrido and Dushnitsky 2013, 2016; Chemmanur et al. 2014). They suggest that the positive effect of CVC funding on R&D investment does not systematically differ between IPO and non-IPO ventures. However, as conjectured previously, IPO ventures appear to be more "successful" because they produce more patents, on average, than non-IPO ventures.

As an alternative test, we analyze data at the industry level, which includes all VC/CVC-funded ventures, regardless of eventual exit status (e.g., IPO, bankrupt, or private), in line with the study by Kortum and Lerner (2000). This analysis includes industry-level CVC disbursement within a production function framework. Consistent with the result in Figure 2, we find that an increase in CVC disbursement at the industry level is associated with an increase in patents for both IPO and non-IPO firms (Table A14 in the online appendix).

In sum, while the analyses above may be less than ideal because of data limitations, our results and prior studies that show that CVC investors positively affect

Figure 2. R&D Output Trends in CVC-Funded Ventures vs. IVC-Only-Funded Ventures for Publicly Traded and Non-Publicly Traded Ventures



a venture's innovation level regardless of its exit status (e.g., Chemmanur et al. 2014) suggest that our main results likely apply to non-IPO, CVC-backed ventures. Therefore, sample selection bias does not seem to be a problem in our study.

Productivity of R&D Expenditure. If knowledge spillover is indeed a key mechanism, as we have argued, then founder managers who utilize knowledge spillover more effectively may positively affect the overall productivity of R&D and, simultaneously, increase the level of R&D expenditure. We can test this effect using our data. Because we have R&D expenditure measures for the three years prior to the venture's IPO, we use each venture's patent count for these three years and compute the venture's productivity by dividing the patent counts by a thousand dollars of R&D expenditure. We find that, in general, the average patent count per thousand dollars of R&D expenditure is greater for CVC-funded ventures compared with IVC-only-funded ventures at the 1% significance level (1.75 versus 0.92; p-value = 0.00), suggesting that CVC-funded ventures enjoy greater productivity from R&D expenditure. However, we do not find a significant difference in the productivity between CVC-funded ventures with and without founders (1.88 versus 1.54; p-value = 0.62). Perhaps further explanation is warranted.

In fact, how a founder's utilization of knowledge spillover affects the venture's overall productivity may depend on the nature of the innovative product and may display heterogeneity across sectors. For example, in the ICT sector, many ventures produce intermediate goods that have relatively shorter development cycles and complement the use of the CVC firm's parent company's finished products. In this case, founders are more likely to utilize subtle knowledge from the spillover and improve efficiency while investing more in R&D because the venture utilizes the user's knowledge (Chatterji and Fabrizio 2011). By contrast, in the BT sector, ventures typically engage in the development of standalone products such as new drugs, agricultural biological products, or treatment services (e.g., gene therapy), which may be radically different from the existing products that large established firms provide, and customization is less likely. These products are typically finished products with longer development cycles that rely more on the distribution, regulatory capabilities (e.g., FDA approval strategy), manufacturing, or industry knowledge of the CVC firm's parent company than on the CVC firm's parent company's current technological knowledge. In this case, founders may engage in new R&D projects due to the knowledge spillover rather than improving the success rate of preexisting innovation projects because they know they can efficiently access the CVC firm's parent company's complementary assets for commercialization. In addition, because of the relatively longer development cycle in the BT sector, while R&D investment may increase for new projects, the expected innovation may not come to fruition ("patents" in our measure) for a long period of time, if ever. (Our measure of productivity covers only a three-year window because of data limitations.) Consistent with this view, Table 6 shows some (weak) evidence that productivity may increase in the ICT sector (p-value = 0.11) but decrease in the BT sector (p-value = 0.11). Table A15 in the online appendix shows the corresponding regression results. These results lend support to our argument, although significantly larger sample sizes with longitudinal data in these subcategories would be ideal.

In sum, we believe that the knowledge spillover utilized by founders in CVC-funded ventures can increase overall R&D spending because founders are better able to recognize innovation opportunities than professional managers are. At the same time, how a founder's utilization of knowledge spillover affects the venture's overall productivity may depend on the nature of the innovative product.

Discussion and Conclusion

CVC investment has increasingly become a major source of entrepreneurial finance that affects the overall governance structure of the investee venture. Thus, it has become all the more important to understand the dynamics among the main stakeholders—CVC and IVC investors and founders—that govern the entrepreneurial firm from the investee venture's perspective. For cash-strapped young entrepreneurial firms in technology-intensive industries, R&D investment is both a significant source of product innovation and a strategic resource-allocation decision made by the venture's governing body, which likely reflects the sharp conflicts of interest among these key stakeholders (e.g., priority of innovation versus commercialization). Thus, in this study, we focus on investigating the effects

Table 6. R&D Productivity Comparison Between ICT and BT Sectors

CVC-funded ventures	Average patent count per thousand dollars of R&D expenditure	Number of ventures	Mean comparison
ICT sector			
Founder incumbent = Yes	3.64	22	1.64 [*t*-value]
Founder incumbent = No	1.42	19	(0.11) [*p*-value]
BT sector			
Founder incumbent = Yes	0.9	40	1.61 [*t*-value]
Founder incumbent = No	1.68	18	(0.11) [*p*-value]

of CVC ownership, founder incumbency, and the CVC investor–founder interaction on the R&D investment strategies of VC-financed, technology-based entrepreneurial firms. In doing so, we provide the organizational mechanisms through which the positive link between CVC investment and the venture's innovation output—which has been well documented in the recent literature (Alvarez-Garrido and Dushnitsky 2016, Chemmanur et al. 2014, Pahnke et al. 2015a, Park and Steensma 2013)—unfolds within the venture. We find that CVC ownership and founder incumbency positively affect entrepreneurial firms' R&D investment and, more importantly, that the CVC ownership effect is effectively amplified when the founder is an incumbent top manager because of goal congruence and knowledge spillover from the CVC firm. Knowledge spillover from CVC investors may occur through various channels and may affect both the level of a venture's R&D intensity and the venture's overall productivity.

However, depending on the idiosyncratic situation of the venture and some key assumptions, our findings can be either value enhancing or value destroying. In fact, our productivity analysis across sectors suggests that both value-enhancing and value-destroying contexts can exist. On the one hand, encouraging more founder leaders and CVC investments in technology-intensive industries can be value enhancing. For example, if we believe that external investors are generally myopic,[16] then the market will heavily discount future income from R&D in favor of more immediate financial gains. As a result, IVC-only-funded ventures may be pressured to invest less than the optimal amount in R&D because IVC firms need to liquidate their investment at the end of their fund's (relatively short) life cycle. In this situation, CVC firms' and founders' propensities for greater R&D investment would partially offset this downward bias and maximize a firm's long-term value. Furthermore, the knowledge created during the R&D process can have nonexclusive, nonrivalrous characteristics, such that CVC firms and founders may use the knowledge in its entirety without owning the entire venture. If, for instance, a CVC firm can use its investee venture as an R&D complement such that the corporate parent can increase its own productivity or if the founder can become a successful serial entrepreneur who utilizes such valuable knowledge (Paik 2014), then the social value may exceed the private value of R&D investment. In such cases, CVC firms' and founders' propensities toward more R&D investment can be socially desirable.

On the other hand, for young entrepreneurial firms, an excessive focus on R&D rather than on building a stable operation more broadly can increase the risk of failure (Ries 2011). An overinvestment in technology is a common mistake that many technology-driven founders make when they are overly focused on innovation rather than investing in the organization's commercialization or professionalization. In addition, if CVC firms use their investee ventures as R&D substitutes to experiment with high-risk, high-return technologies (and free ride on other investors), then the results documented in this study may reflect a unique agency problem that may not be prudent for the venture itself; that is, CVC firms may be "fattening the cow" for their own private benefit by inducing the venture to overinvest in R&D because the parent corporation can benefit from the valuable knowledge generated during the R&D process, even if the project fails. In this case, VCs may be the rational actors who mitigate the above-mentioned unique agency problems. Thus, rather than portraying an overly rosy picture of the "value-adding role" of CVC firms, we note that overinvestment in R&D can be a unique problem ex post in addition to the ex ante technology misappropriation problem inherent in the "paradox of CVC" (Dushnitsky and Shaver 2009, Katila et al. 2008).

Contributions and Implications

This study contributes to the technology entrepreneurship literature (e.g., Dushnitsky and Shaver 2009, Park and Steensma 2012) by articulating the organizational mechanisms at work when CVC investors and founders interact. Scholars have traditionally focused on understanding the main motivations behind CVC activity and its impact on the investing corporate firm (e.g., Basu et al. 2011; Benson and Ziedonis 2009; Dushnitsky and Lenox 2005a, b, 2006; Wadhwa and Kotha 2006). These studies show that acquiring knowledge from entrepreneurial ventures is one of the primary

strategic objectives of CVC investment (Dushnitsky and Lenox 2005a, b; Smith and Shah 2013) and thus emphasize the inherent ex ante conflict between CVC investors and entrepreneurs due to technology misappropriation (e.g., Dushnitsky and Shaver 2009, Katila et al. 2008). By contrast, our study shows a knowledge spillover from the corporation to the entrepreneurial venture and reveals that founders more effectively take advantage of this spillover when interacting with CVC investors because of their technological expertise, motivation, tacit knowledge, entrepreneurial spirit, longer planning horizon, and other characteristics that stem from their "ownership plus" mentality. As a result, the investee venture experiences increased R&D investment due to the goal congruence between the CVC investor and the entrepreneur ex post funding. Furthermore, our findings importantly complement some recent studies that find that CVC-funded ventures tend to have superior innovation output measured in patents (Alvarez-Garrido and Dushnitsky 2016, Chemmanur et al. 2014). These findings show that this superior performance may be the result of the venture's increased resource commitment to R&D and, in some cases, increased productivity due to knowledge spillover. Thus, this study joins the recent literature on CVC firms from the investee's perspective (Alvarez-Garrido and Dushnitsky 2016, Park and Steensma 2013) and broadly speaks to the significance of investor heterogeneity in the entrepreneurial finance literature (e.g., Alvarez-Garrido and Dushnitsky 2016, Pahnke et al. 2015a). Overall, our results demonstrate that CVC investors not only provide financial resources but also affect venture strategy through significant ownership and that founders effectively utilize knowledge spillover from CVC investors. This finding is in line with the argument that owners and investors play an important role in shaping the strategies of established firms (e.g., Fiss and Zajac 2004).

This study also has implications for agency theory and the corporate governance literature. While research on principal–agent conflicts (Berle and Means 1932, Jensen and Meckling 1976) dominates the corporate governance literature, a growing body of literature on principal–principal conflicts departs from the core assumptions of classical agency theory (e.g., Connelly et al. 2010, Young et al. 2008). For example, Young et al. (2008) note that corporate governance in emerging economies with family firms provides a context in which principal–principal conflicts are a major concern. Our study suggests that entrepreneurial financing and the corporate governance in entrepreneurial ventures are additional contexts in which such principal–principal conflicts are severe. The board composition of entrepreneurial ventures differs vastly from that of large established corporations (Baker and Gompers 2003), and the classical agency problems between shareholders and managers that stem from the separation of ownership and control, which are prevalent in large established corporations, are less severe or almost nonexistent in founder-led entrepreneurial ventures (Wasserman 2003, 2006). Accordingly, we adopt a new perspective to elucidate R&D investment strategies in entrepreneurial ventures because of the unique board and manager characteristics in the entrepreneurial firm context and, importantly, complement studies such as that by Kor (2006), which examines the effects of board and manager characteristics on R&D investment strategies in large publicly traded corporations.

Limitations and Future Research

Similar to all studies, this paper has some limitations. First, because of data limitations, we are not able to perform the desired in-depth analysis of non-publicly traded, privately held ventures. Nonetheless, the limited data available to researchers are consistent with our theoretical argument. Second, while we attempt to address certain endogeneity concerns, this study relies on cross-sectional data only and focuses on significant stakeholders at the time of the IPO. Thus, we cannot rule out all alternative explanations and establish clean causality. If panel data on the internal firm characteristics of the privately held ventures considered in this study become available in the future, scholars can explore the dynamics of entrepreneurial firms more deeply, as the results that we document in this study may be confined to the circumstances surrounding ventures at the time of the IPO. Third, another avenue for future research involves precisely measuring the theorized mechanisms that underlie the effect of CVC ownership in driving the R&D investment strategies of young entrepreneurial ventures and examining the relative importance of such mechanisms in various contexts. In other words, future scholars can investigate the relative importance of the direct corporate governance effect, the CVC investor–venture interaction effect, and the technology endorsement effect.

In conclusion, despite some limitations, our study significantly improves our understanding of the effects of CVC investors, founders, and their interactions on entrepreneurial firms' R&D investment strategies. We hope our study can serve as a stepping-stone to advance our understanding of the organizational dynamics in entrepreneurial firms.

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Endnotes

[1] CVC investments have accounted for, on average, 7% of the venture capital industry. More recently, the share of CVC investments has increased significantly, reaching 21% of all deals by the end of 2015, according to the National Venture Capital Association (Veghte 2016). Thus, given the increasing importance of CVC investments in recent years (Taylor 2013), we believe that CVC investment remains an understudied topic in the literature.

[2] R&D expenditure enables an entrepreneurial firm to recruit and retain star scientists/engineers, obtain licenses for key technologies, and gain access to external intellectual property. A major part of R&D expenditure technically consists of R&D employee wages, research equipment expenditure, and, beginning in 2006, stock-based compensation under the Statement of Financial Accounting Standards (Czarnitzki and Hottenrott 2011).

[3] In our setting, knowledge spillover is mostly due to unanticipated knowledge diffusion, but some knowledge spillover may be a result of market-mediated transactions (e.g., a formal research alliance between the venture and the CVC firm).

[4] For example, during our interview, a CVC manager from a solar panel manufacturer that invested in a solar leasing start-up stated that when the investee start-up considered developing and launching a system to manage nationwide contractors (installers), the CVC firm supported this strategy because it could be beneficial to its core business in the solar panel market. However, an IVC investor strongly opposed this strategy because it could have negatively influenced the venture's "numbers" at the time of the IPO.

[5] In our sample, the correlation between CVC ownership and CVC investor's board membership is 0.6377 (p-value = 0.001). However, obtaining voting seats *with* control rights may be the exception rather than the rule due to the fear of litigation for not fulfilling fiduciary duties, especially if CVC investors and the new venture compete in the same industry.

[6] Our interviews with practitioners confirm this view. For example, GridNet is a smart grid start-up that has an array of smart grid products, including two software platforms. Because the technical standards for smart grid products are still in their infancy, GridNet faced a high risk. However, when Cisco invested in GridNet, the risk decreased significantly because Cisco formed a "Smart Grid Technology Advisory Board" to lobby for the adoption of an Internet protocol standard for smart grid communications (Lombardi 2010). Such support from a CVC investor helps investee ventures develop their technology with confidence.

[7] Therefore, our construct of founder incumbency is meaningfully different from the construct of the founder CEO, which is the dominant paradigm in the literature (e.g., Nelson 2003, Souder et al. 2012). We empirically verify this in our data.

[8] In principle, knowledge spillover can affect both the overall productivity of R&D expenditures and the level of investment in R&D. Hence, we investigate this issue later in our empirical analysis and test some of our hypothesized mechanisms by examining different forms of CVC programs, CVC investor's board membership, industry heterogeneity, and founder background heterogeneity.

[9] In our results section, we empirically test various mechanisms that support our hypotheses by utilizing the data on CVC investor's board membership, CVC investor heterogeneity, the founder's technological background, the investee venture's industry heterogeneity, etc.

[10] Alternatively, because Form S-1 reports up to three years of R&D expenditure data prior to the venture going public, we obtain R&D expenditure data from the last three years that the venture was private and use the three-year average (as well as data from $t-2$ and $t-3$ years, separately, as a robustness test) as our dependent variable to placate any concerns regarding "window dressing" immediately prior to the IPO. All results are qualitatively similar using these alternative approaches. In addition, professional agent managers' temporary window dressing behavior immediately before an IPO, which may be backed by IVC investors via goal congruence, cannot be the driving force of our results because it is inconsistent with the extant literature, which documents persistent differences in the long-term investment behavior of founder CEOs and professional CEOs in large established corporations, even after the IPO (e.g., Fahlenbrach 2009).

[11] Some IPO firms have shareholders other than VC firms, CVC firms, and founders. Such shareholders include individual investors, universities, pension funds, bank-affiliated organizations, and other financial institutions. Shares that are owned by these other shareholders are relatively minor, especially at the time of IPO. Thus, they are omitted from the analysis for the construction of control variables. In addition, even after the shares held by these minority shareholders are excluded, the sum of *CVC ownership*, *founder ownership*, and *VC ownership* can approach close to 100% ownership. Hence, these variables do not vary entirely independently of one another. Nonetheless, we do not encounter any multicollinearity problems in our regression models.

[12] One rule of thumb in applied econometrics is that a study should have at least 10 observations per right-hand-side independent variable that is included in the regressions (Draper and Smith 1998). Because the number of observations in our analysis is $N = 319$, we include only a limited number of dummy variables for the industry and state fixed effects to avoid falling short of the degrees of freedom. In our regression models, we have four state dummies (i.e., California, Massachusetts, New York, and New Jersey) and five industry dummies (Standard Industrial Classification (SIC) codes 73, 28, 38, 36, and 35), which represent the most frequent states and industries. The industries are as follows: SIC 73, business services including computer programming and data processing; SIC 28, chemicals and allied products; SIC 38, measuring, analyzing, and controlling instruments; photographic, medical and optical goods; and watches and clocks; SIC 36, electronic and other electrical equipment and components, except computer equipment; and SIC 35, industrial and commercial machinery and computer equipment. The omitted groups are the groups that represent all other states and all other industries. Therefore, the total number of independent variables in the full regression model is 19, and our sample size ($N = 319$) is significantly larger than the rule of thumb of 190.

[13] We do not run a PSM analysis that tests the effect of *CVC ownership* because it is a continuous variable rather than a dichotomous treatment and because we are interested in the level of "treatment" rather than CVC funding itself. However, although sample size is significantly reduced, we run a *doubly robust regression* with matched samples (Funk et al. 2011) to test the CVC ownership effect and find consistent results.

[14] Although our STATA results do not report any shortage concerning the degrees of freedom, we caution our readers to consider the likelihood of small sample size problems when interpreting our results.

[15] From here on, because of the sample size and because we have only one instrumental variable, we present OLS results rather than using two-way or three-way interaction terms in a 2SLS regression framework.

[16] In other words, this would mean that investors are not fully rational and have "present-biased preferences" (or, more generally,

time-inconsistent preferences) with hyperbolic discounting (Frederick et al. 2002, Laibson 1997, Thaler 1981) rather than the traditional exponential discounting that is implicitly assumed in valuation models. Systematic biases due to time-inconsistent preferences have been repeatedly reported in the psychology and economics literature (e.g., Green et al. 1994, Kirby 1997, O'Donoghue and Rabin 1999).

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