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Entrepreneurial Firm’s Corporate Governance and R&D Investment Strategy: The Effects of Corporate Venture Capital Ownership, Founder Incumbency, and Their Interaction

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Abstract

Every organization is subject to a host of external and internal forces that shape their activities and performance. Moreover, these forces are intimately interrelated. In the context of young entrepreneurial ventures in technology-intensive industries, R&D investment strategy is likely one immediate facet affected by these forces because R&D investment is inherently a high-risk, high-return strategy that requires constant support from shareholders and top managers. Thus, understanding the corporate governance-related mechanisms underlying the R&D investment strategy of technology-based entrepreneurial ventures is important because R&D investment is both a significant source of product innovation and a strategic resource-allocation decision made by the governing body of the venture, which likely reflects the sharp conflict of interests among key stakeholders (e.g., priority of innovation vs. commercialization). To shed light on such corporate governance-related mechanisms, we focus on the most significant stakeholders in these young entrepreneurial ventures – venture capital (VC) firms, corporate venture capital (CVC) firms, and founders. We gain insight from the technology entrepreneurship literature to present our theoretical argument and to form testable hypotheses and articulate the organizational mechanisms underlying the effects of CVC ownership, founder incumbency, and their interaction on VC-financed entrepreneurial venture’s R&D investment strategy. 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 founders utilize knowledge spillover more effectively than professional agent-managers do. Our empirical analysis supports our hypotheses while addressing potential endogeneity concerns.
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INTRODUCTION
External and internal pressures shape organizations’ trajectory and affect their strategy and performance. One may even expect to find subtle interactions between external and internal pressures. For firms in technology-intensive industries, R&D investment strategy is likely immediately affected by these forces because such investment is inherently a high-risk, high-return strategy that requires constant support from shareholders and top managers (e.g., CEOs) (Aghion et al. 2013). The benefits of an R&D investment are not immediate. Furthermore, whether R&D investment will indeed result in innovation and whether it constitutes an effective strategy for firms with limited resources are unknown. In fact, given that each stakeholder may have a different preference when allocating resources to innovation, some stakeholders may prefer to allocate more resources to commercialization than to innovation.

In particular, understanding a young entrepreneurial firm’s investment in R&D, especially in technology-intensive industries, is important for two reasons. On the one hand, such investment is a primary source of innovation (e.g., Hausman et al. 1984) and can make a significant difference in the firm’s long-term performance by accelerating new product development and building technological and learning capabilities (Audretsch and Feldman 1996; Cohen and Levinthal 1990; Porter 1985). On the other hand, it is a strategic resource-allocation decision made by the firm’s governing body that is a manifestation of a sharp conflict of interest among key external and internal stakeholders. By examining a technology-based entrepreneurial firm’s investment in R&D, we can gain a better understanding of the unique corporate governance-related determinants of R&D that differ significantly from those in the established firm context. Because investing in a startup venture is very risky and because shares are not publicly tradable until the firm goes public, specialized investors such as independent venture capital (IVC) firms and corporate venture capital (CVC) firms dominate the investment market and, along with founders, govern entrepreneurial firms (Dushnitsky and Lenox 2005a; Gompers and Lerner 2004). Despite these considerations, prior studies examine only large public corporations (e.g., Barker and Mueller 2002; Baysinger et al. 1991; Kor 2006) and remain silent about the corporate governance-related determinants of R&D investment strategies in early-stage entrepreneurial firms.

Thus, given such dual significance, the purpose of this study is to examine the corporate governance-related determinants of R&D investment strategy in technology-based entrepreneurial ventures financed by venture capital (VC). In doing so, we aim to provide a novel explication of the organizational mechanisms leading to greater investment in R&D, especially in regards to the interaction between external investors and internal management. IVC firms, CVC firms, and founders are generally considered to be the most influential stakeholders in the venture capital market (Dushnitsky and Shaver 2009; Gompers and Lerner 2000). Therefore, in the context of VC-financed entrepreneurial ventures, we focus on the role of CVC investors (in comparison with IVC investors), founder-managers, and their interactions to better understand how these stakeholders can shape the entrepreneurial venture’s allocation of resources to R&D. 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, CVC, and founders) stemming from heterogeneous preferences.

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1 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 (SFAS) (Czarnitzki and Hottenrott 2011).

2 CVC investments accounted for, on average, 7% of the venture capital industry. More recently, the share of CVC investments has increased significantly, reaching 17% by the end of 2013, according to the National Venture Capital Association. Thus, given the increasing importance of CVC investments in recent years (Taylor 2013), we believe that CVC investors remain an understudied topic in the literature.

3 While this study primarily aims to identify the relative propensity to invest in R&D of the three key stakeholders of an entrepreneurial firm, we also provide our interpretation of whether the behaviors that we identify in this study are value maximizing in the discussion section.
We gain insight from the technology entrepreneurship literature on CVC (e.g., Dushnitsky and Lenox 2005a; Park and Steensma 2012) and founders (e.g., Boeker and Karichalil 2002; Wasserman 2003). Although these two streams of literature have been largely developed in isolation to date, we consider them separately and jointly to present our theoretical argument and form testable hypotheses. We articulate the mechanisms underlying the effects of CVC ownership and founder incumbency on a venture’s R&D investment strategy and then pose an integrated theoretical argument on the novel mechanism underlying the interrelationship of the two effects. We argue 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, rather than emphasizing the canonical conflict between CVC investors and entrepreneurs (e.g., Dushnitsky and Lenox 2005a, b) and the knowledge that established incumbent firms acquire via CVC investment (e.g., Dushnitsky and Shaver 2009; Smith and Shah 2013), we argue that the positive CVC ownership effect is effectively amplified when the founder is an incumbent top manager due to goal congruence and knowledge spillover from the CVC investor. Our empirical results are consistent with our theoretical argument and remain robust even after potential endogeneity concerns are addressed. This study sheds new light by identifying novel mechanisms underlying the significant impact of CVC investors, founders, and their interaction on young entrepreneurial firms’ R&D investment strategies and joins the emerging literature on corporate investors from the investee’s perspective (e.g., Alvarez-Garrido and Dushnitsky 2015; Park and Steensma 2012, 2013).

Our work is closely related to that of Alvarez-Garrido and Dushnitsky (2015) and that of Chemmanur et al. (2014), which show that CVC-funded ventures exhibit greater innovation output, as measured in patents or publications. Chemmanur et al. (2014) suggest that CVC’s greater tolerance for failure and greater industry knowledge are the two mechanisms that enable CVC-funded ventures to have greater innovation output relative to IVC-only-funded ventures. Based on their study of biotech firms, Alvarez-Garrido and Dushnitsky (2015) suggest that an investee venture’s access to complementary assets (FDA approval knowledge and corporate facilities) that the CVC parent company possess is the main factor that contributes to the investee venture’s greater innovation output. Our study importantly complements these two 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 (an input to innovation)4. Furthermore, our study focuses on the internal organizational dynamics among IVC, CVC, and founders of the venture’s governing body. Therefore, our study contributes to the broader corporate governance and entrepreneurship literature by focusing on the internal mechanisms overlooked by prior studies and on firm behavior (e.g., resource allocation strategy) rather than performance (e.g., patents).

THEORY AND HYPOTHESES

The CVC ownership effect

In a standard VC investment cycle, IVC firms raise capital from limited partners (e.g., pension funds, endowments, and wealthy individuals) to form VC funds, which typically have a fixed life of ten years, to invest in high-risk, high-return ventures in technology-intensive industries. These firms’ ultimate goal is to generate substantial financial returns via an IPO or a trade sale of the portfolio company (Gompers and Lerner 2004). By contrast, CVC firms are typically structured as subsidiaries of incumbent corporations with their own lines of business (Dushnitsky and Shaver 2009). These firms procure the funds for their investments in portfolio firms from their parent corporations (Chemmanur et al. 2014), do not adopt high-powered performance-based managerial compensation schemes (e.g., carried interest) (Dushnitsky and Shapiro 2010), and take a minority equity stake in privately held entrepreneurial ventures (Gompers and Lerner 2000). As strategic investors, CVC firms mainly pursue strategic benefits from their investment in young entrepreneurial firms (Dushnitsky and Lenox 2005a; Hellmann 2002). 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). Young entrepreneurial ventures are potentially an important source of knowledge for established corporations, which are able to facilitate the firm’s learning through CVC investment (Dushnitsky and Lenox 2005b). If a CVC-backed venture does not create valuable knowledge, the CVC firm’s strategic benefits will be limited. Therefore, CVC investors have an incentive to support its portfolio company’s continued effort in R&D, thereby increasing the venture’s R&D intensity.

4 Thus, the venture’s overall productivity due to R&D expenditure remains ambiguous. Although productivity is not the focus of the current study, we provide a preliminary productivity analysis to extend our findings.
CVC investors can drive entrepreneurial firms’ investment in R&D in several ways. First, CVC investors with significant ownership can maintain board seats or board observation rights (Dushnitsky and Lenox 2005b) and can offer their opinion regarding the venture’s strategic direction in board meetings (direct corporate governance effect). When CVC firms invest in an entrepreneurial venture, they typically co-invest with IVC firms, forming a VC syndication (Lerner 1994). However, IVC firms and CVC firms have different primary investment objectives (i.e., financial vs. strategic returns), which may lead to a potential conflict of interest (Park and Steensma 2013). Because R&D investment does not always increase firm value in the short run, IVC firms with fixed investment cycles may not fully support substantial R&D as they approach the end of the investment cycle. Rather, IVC firms may prefer to have managers increase market share via product commercialization, accelerate marketing activities to increase the number of customers, promote the venture to outside stakeholders, or improve brand awareness. By contrast, CVC firms are interested in new technologies and the potential synergy between these technologies and the business of the CVC parent company; they often regard CVC investment as ‘R&D outsourcing’ (Basu et al. 2011). Although an entrepreneurial firm’s R&D investment may not always lead to a positive financial outcome, CVC firms may encourage the managers of a venture to continue pushing a project if that project could benefit the CVC parent company’s core business. This CVC-IVC conflict stemming from a difference in investment objectives can become particularly salient if the venture approaches a major liquidity event (e.g., IPO). For example, our interview with a CVC investment manager working for a Silicon Valley-based solar panel manufacturer that has invested in a solar leasing startup revealed that when the solar leasing startup considered developing and launching a system to manage nationwide contractors (installers), the CVC firm supported this strategy because it believed that the system could help its core business in the solar panel market. However, an IVC investor strongly opposed this strategy because it could negatively influence the venture’s ‘numbers’ at the time of the IPO. This example illustrates how differences in the primary investment objectives of investors in VC syndication can result in sharp conflicts. Thus, when CVC investors hold greater ownership, they are more likely to maintain a board seat to have a direct influence on issues that require the board's approval (e.g., approving business strategy) (Baker and Gompers 2003) and implement broader interventions that counterbalance the IVC firm’s preferences. Through such intervention, a CVC firm can influence how its portfolio company reflects its interests. In practice, as CVC ownership constitutes a greater share of the total investment, a CVC firm becomes more likely to observe observer seats, secure protective provisions (i.e., veto rights), and even obtain voting seats with control rights. Second, direct interactions with the CVC firm and its corporate parent can affect the R&D investment strategy of a portfolio company (CVC-venture interaction effect). For example, as ownership stakes increase in portfolio companies, the CVC’s parent corporation becomes more likely to provide its portfolio companies with opportunities to use its corporate infrastructure for product development, manufacturing, distribution, and so on (Chesbrough 2002; Dushnitsky and Shaver 2009) or share information with its portfolio companies and offer them advice based on its expertise. Such support can help the entrepreneurial venture save time and resources and can encourage it to focus more on R&D while still providing access to complementary assets that facilitate commercialization (Gans et al. 2002; Teece 1986). For instance, Microsoft provides its portfolio software ventures ‘with tools and services that enable companies working with them to develop their ideas and adapt their products to work with the latest technologies’ (Brian 2011). However, non-portfolio companies cannot easily expect such support in an arm’s length transaction (Williamson 1975) with established corporations because corporations will not have much interest in the long-term success of the transacting partner. However, by holding an equity stake in the entrepreneurial venture, CVC firms can mitigate this problem and support the entrepreneurial venture’s long-term commitment to R&D (Diestre and Rajagopalan 2012).

Finally, in some cases, CVC investors can resolve the risk and uncertainty regarding technology standards that ventures face at the nascent stage of industry (Shapiro and Varian 1999). Relative to established firms, new ventures developing novel technologies suffer from greater technological uncertainty (Toh and Kim 2012) due to their lack of legitimacy (Zimmerman and Zeitz 2002). Because of the market’s widespread uncertainty regarding the ultimate acceptance of an entrepreneurial firm’s novel technology as an industry standard, entrepreneurial firms

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5 In our sample, the correlation between CVC ownership and CVC board membership is 0.6377 at the 1% significance level. That is, as CVC ownership increases, the likelihood that an individual from the CVC firm sits on the investee venture’s board increases. However, obtaining voting seats with control rights may be an exception rather than the rule due to fear of litigation for not fulfilling fiduciary duties, especially if CVC investors and the new venture compete in the same industry or have greater potential to have conflicts of interest.
may hesitate to fully commit resources to technological development. However, when an established incumbent in the industry backs the venture’s technology with a significant ownership stake, this relationship is more likely to be publicly disclosed. As a result, the widespread uncertainty can be significantly reduced owing to a technology endorsement effect, and the venture can invest more extensively in R&D. This technology endorsement effect has not received much attention in the literature to date; however, it is certainly an important resource for young entrepreneurial ventures in technology-intensive industries that IVC firms cannot offer. Our interviews with practitioners confirm this view. For example, GridNet is a smart grid startup that has an array of smart grid products, including two software platforms. Because the technical standards for smart grid products are still in the infancy stage, GridNet faced 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 (IP) standard for smart grid communications (Lombardi 2010). Such support by a CVC firm helps investee ventures develop their technology with confidence. When the corporate investor is also a potential downstream customer of the entrepreneurial firm’s product, it is even easier for the entrepreneurial firm to invest more in its technology because CVC investment practically secures a built-in buyer. Thus, unlike IVC investors’ support, the support of CVC investors can benefit entrepreneurial firms in both the investment and the product markets.

Based on the considerations outlined above, all else being equal, greater CVC ownership in a new venture will lead to increases in the venture’s R&D intensity compared with IVC-only-funded ventures’ R&D intensity. Furthermore, as the CVC firm’s power based on ownership increases, its preferences relative to IVC firm preferences can be increasingly reflected in the entrepreneurial venture’s R&D investment strategy.

Hypothesis 1. Greater CVC ownership of an entrepreneurial venture is positively associated with the entrepreneurial venture’s R&D intensity.

Next, we articulate the mechanism underlying the effect of founder incumbency on a venture’s R&D investment strategy. We then turn to discussing the novel mechanism underlying the interrelationship of the CVC ownership and founder incumbency effects.

**The founder incumbency effect**

Understanding the behavior of a firm’s founder-manager is important because 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 founder-managers and professional agent-managers are particularly stark in young entrepreneurial firms (Wasserman 2006). To illustrate such differences, scholars have noted that 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 in regard to the knowledge, values, and attitudes that they bring to managing firms (Jayaraman et al. 2000). In addition, founders often view their firms as extensions of themselves (Wasserman 2012) or describe their businesses as their ‘babies’, expressing a personal connection and even identification with their businesses (Cardon et al. 2005). Accordingly, founder-managers have a stronger commitment to their firm and may have a longer investment horizon compared with agent-managers, who typically have relatively shorter-term contracts (Carroll 1984). 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 non-financial investments of time, energy, and sweat equity.

Above all, founder-managers are, in essence, entrepreneurs. Scholars have noted that entrepreneurs more effectively handle ambiguous situations and identify entrepreneurial opportunities (Baron 2006). Entrepreneurs also have better risk-bearing capacity (Sarasvathy et al. 1998) and possess more tacit knowledge about the venture’s technology (Koskinen and Vanharanta 2002) than agent-managers. Accordingly, these entrepreneurial traits may enable founder-managers to pursue certain types of innovation projects that agent-managers may avoid or neglect.

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6 Some scholars have used the term ‘overconfidence’ (i.e., the cognitive bias of overestimating one’s own ability) to explain such behavior. In fact, some evidence (through survey questions) shows that founder-managers may be more overconfident than agent-managers (Forbes 2005). However, a study conducted by Galasso and Simcoe (2011) shows that overconfidence actually leads to more innovation. Thus, in the context of innovation (as opposed to firm performance more broadly), overconfidence is a misleading term because ‘overconfident’ founder-managers are correctly estimating their own ability and achieving a superior innovation outcome relative to agent-managers (i.e., there is no bias). Hence,
Furthermore, founder-managers may more easily recognize lucrative innovative projects that are worth pursuing than agent-managers. At the same time, founders expect to remain with the venture for a sufficient time to reap the benefits of R&D investment. Wasserman (2003) echoes the idea that founder-managers of technology-based ventures support product development more than any other endeavor.

Founder-managers may even have a propensity to invest more in existing R&D projects. In technology-intensive industries, founders generally base their businesses on novel and creative technological ideas. 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 capability and accomplishment in the market (Cardon et al. 2012). In some cases, this psychological attachment to the venture may drive a founder to pursue perfection in technology development even at the expense of missing a deadline for a prototype or exceeding budget. This spirit of craftsmanship is often observed in founder-managed, small business firms (Daily and Dalton 1992).

Founders’ R&D investment preferences, however, can be reflected in firm strategy only when founders are incumbent top managers (e.g., CEOs or CTOs). In other words, founders can exert their influence on firm strategy when they have legitimacy and structural power based on hierarchical authority (Finkelstein 1992). Our construct of founder incumbency in entrepreneurial ventures is meaningfully different from the construct of founder-CEO7, which is the dominant paradigm in the corporate governance literature based on established corporations (e.g., Nelson 2003; Souder et al. 2012). For instance, Google’s co-founders Sergey Brin and Larry Page actively participated in the firm’s strategic decision making even after stepping down as CEOs and bringing in a more seasoned executive manager, Eric Schmidt. Thus, all else being equal, ventures with founders as incumbent managers in technology-intensive industries are expected to invest in R&D activities to a greater extent than ventures without founders in this role.

Hypothesis 2. 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
Overall, we argue that the effect of CVC ownership will differ depending on whether the founder is an incumbent top manager in the entrepreneurial venture. We have highlighted three primary mechanisms through which CVC investors can influence their investee company’s R&D investment: i) the direct corporate governance effect, ii) the CVC-venture interaction effect, and iii) the technology endorsement effect. While the technology endorsement effect primarily works through external market signaling (and, thus, is irrelevant to whether the founder is an incumbent top manager), the other effects enhance R&D investment through mechanisms internal to the investee firm and may depend on whether the founder is an incumbent manager.

Interaction with CVC firms, for example, provides an opportunity for knowledge spillover, which becomes a significant source of innovation. Knowledge spillover can occur when the venture’s top managers interact with developers (i.e., scientists and engineers), legal experts, marketing managers, or other key personnel of the CVC’s parent company or when they interact with CVC investors during board meetings (in the form of advice, feedback, open discussion, etc.). These interactions may include product testing, brainstorming, and other formal/informal conversations that provide various forms of technological and market knowledge feedback. In addition, knowledge spillover can occur when managers of portfolio companies attend CVC-sponsored annual conferences (e.g., Intel Global Summit) or participate in other forms of CVC-sponsored startup assistance programs (e.g. The Bridge by Coca-Cola). Our interviews with industry practitioners also indicate the importance of ‘secondary knowledge spillover’ from other portfolio companies that individuals obtain when attending these programs for their innovation projects. Furthermore, during our interviews, CVC investors reported that their value-adding role includes serving as an intermediary or liaison between their portfolio companies and the CVC parent company’s suppliers, buyers, and other key industry players. Thus, knowledge spillover can also occur through interactions with industry players that CVC investors introduce to portfolio companies.

As CVC ownership of the venture increases, the likelihood that such knowledge spillover via various sources will occur more broadly and more frequently increases. Founder-managers can utilize such knowledge spillover to recognize new opportunities and initiate more innovation projects that require more R&D investment because of their inherent entrepreneurial trait, tacit knowledge about the venture’s own technology, and longer planning horizon. We

we prefer the term ‘entrepreneurial traits’ as our mode of explanation. For a review of the multiple measures and definitions of overconfidence and the mixed results in the entrepreneurship literature, see Åstebro et al. (2014).

7 We empirically verify this in our data. Results are available upon request.
compare such managers with professional agent-managers, who are mostly recruited for their superior general management skills and have relatively shorter fixed-term contracts.

In addition to increasing the quantity of 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-managers. Professional-managers, who are typically brought in by IVCs, have goals that are congruent with those of IVC firms in terms of maximizing financial returns. However, in regard to R&D, founder-managers and CVC firms may have goal congruence in terms of greater investment in R&D. CVC firms also have greater tolerance for failure (Chemmanur et al. 2014; Manso 2011) relative to IVC firms due to the differences in how CVC funds are structured and how CVC fund managers are compensated (Dushnitsky and Shapira 2010). Thus, when the founder is an incumbent top manager and a CVC firm backs the venture, longer-term projects pursuing relatively radical innovation are more likely to be proposed and funded, which may require a greater commitment of resources to R&D.

Hence, we expect CVC’s positive effect on R&D investment, as outlined in H1, to be greater when the founder is an incumbent top manager in the entrepreneurial venture because the amount and type of innovation projects can differ based on the founder’s role.

Hypothesis 3. 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 (SEC) (e.g., ownership data). We employ data from VentureXpert to set 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 funded as early as 1986 or as late as 2009. In this period, CVC activity became prevalent (Gaba and Meyer 2008), and our sample includes both IVC-only-funded ventures and CVC-funded ventures. In most cases, VC firms co-invest with CVCs (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 must consist 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 non-founder-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 that corresponds to data when the venture was a private firm (i.e., prior to the IPO year). We do not use data ex-post IPO because a venture’s corporate governance 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 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 medical/health/life science sector (e.g., biotechnology and pharmaceutical firms; henceforth, “BT sector”) according to the VentureXpert industry classification, and we exclude non-technology-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

8 Knowledge spillover can affect the overall productivity of R&D expenditure and the level of investment in R&D. We investigate this issue later in our empirical analysis and tease out some of our hypothesized mechanisms by investigating different forms of CVC programs, CVC board membership, and founder background heterogeneity.
entrepreneurial ventures, we limit our sample to firms that were twenty years or younger at the time of 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.

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%) considering 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, excluding seed-stage ventures. Therefore, within this sub-population 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 set of firm characteristics, it may be subject to sample selection problems because CVC firms, compared with IVC firms, may invest in more R&D-intensive, and thus successful, ventures. We discuss this issue in more detail below. Throughout our analyses, the unit of analysis is the venture.

Measures

Dependent variable

Our dependent variable 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. Our sample includes young ventures, which often have very low and unstable sales. This 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 an accurate measure for established firms, it is not an accurate variable for young entrepreneurial ventures. By contrast, 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

CVC ownership. For CVC ownership, we measure the proportion of shares held by CVC firms, calculated as the percentage of the total number of shares of the venture. 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. Founder incumbency takes the 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 co-founders 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

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9 As a robustness check, we examine a conservative sample of firms that were fifteen years or younger at the time of IPO, reducing the sample by 4%. All results remain qualitatively similar.

10 Alternatively, because Form S-1 reports up to three years of R&D expenditure data prior to the venture going public, we take R&D expenditure data from the last three years 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 IVCs via goal congruence, cannot be the driving force of our results because this 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).
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 previously discussed, different types of investors may have heterogeneous preferences regarding R&D investment (Hoskisson et al. 2002; Kim et al. 2008). The influence of CVC 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 percentage 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 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 vs. outsider) affect firm R&D investment. To control for these effects, we include number of inside board members, number of outside board members, and CEO-chairman duality, which takes a value of 1 if the CEO is also the chairman and 0 otherwise.

Pre-IPO financing processes that a startup 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 fund raising rounds, the natural log of total invested amount (i.e., total amount of funding that a focal venture received from IVC/CVC firms and other investors prior to an IPO), and the number of total investors (i.e., total number of investors backing the focal venture). We also include industry and state fixed effects in our regressions. All standard errors are clustered at the lead investing firm level.

Analytical approach
Selection bias
To test our hypotheses, we first examine how CVC ownership and founder incumbency are related to the R&D intensity of an entrepreneurial venture by using ordinary least squares (OLS) regressions. However, 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 be a mere 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 parent company’s core business (Dushnitsky and Lenox 2006). In contrast to prior studies, however, 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 Heckman 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 Heckman two-stage estimation procedure. All ventures enter the database once they receive a first round of venture capital funding from an external investor. Furthermore, some are funded by a CVC at t1, whereas others are not. We then capture our outcome variable, R&D intensity, at t2, which is the last year in which the venture was private before eventually going public at t3. Our first-stage Heckman selection model estimates the propensity for new ventures to receive CVC funding given the initial venture characteristics at t0. In addition, a Heckman selection model must 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 2015; Park and Steensma 2012) and use the availability of CVC funds at the industry

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 purpose of constructing 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 independent of one another. Nonetheless, we do not encounter any multicollinearity problems in our regression models.
level. Similar to Brander et al. (2015), we assume that it 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 investments across all CVC firms that are active in the focal year (industry level). This measure reflects that amount of money available for investment purposes at the industry level; we assume that this value is beyond the control of any focal entrepreneurial venture. As in prior CVC studies (e.g., Alvarez-Garrido and Dushnitsky 2015; 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., at 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., \( \tau = (t_2 - t_0) \), from the subset of CVC-funded ventures and use \( t_0' = t_0 + \tau \) for IVC-only-funded ventures to determine the availability of CVC funds. In our sample, \( \tau = 2.3 \) years. In addition, we assume that our industry-level measure of 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 assumption may be reasonable\(^{12}\). The data on CVC fund availability are obtained from the National Venture Capital Association (NVCA) and are measured annually. Therefore, we use a 2-year lag in our regressions. As a robustness check, we also use a 3-year lag, and the results are fully robust to this alternative specification\(^{13}\). The NVCA data only start in 1995; thus, we lose 7 observations (2.2\%) due to missing data when we run the Heckman model.

Insert Figure 1 here’

From the first-stage selection equation, we compute the inverse Mills ratio (\( \lambda \): 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:

\[
\begin{align*}
\text{Prob} (\text{CVC} = 1) &= \Phi(Z_{Y_1}) \\
E(y| \text{CVC} = 1) &= X'\beta + \rho s \Phi(Z_{Y_1}) \\
\lambda(Z_{Y_1}) &= \frac{\phi(Z_{Y_1})}{\Phi(Z_{Y_1})} \\
\end{align*}
\]

where, in the first-stage selection equation, \( \text{CVC} = 1 \) 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 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/Startup/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. \( \lambda \) is the inverse Mills ratio computed from the first stage to correct for any selection bias.

**Reverse causality**

In addition to the selection bias noted above, reverse causality is a concern (e.g., Singh and Mitchell 2005). That is, a CVC firm’s ownership of a new venture at the time of 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 may retain more ownership of the venture. By contrast, if the venture does not sufficiently invest in R&D, the CVC 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). Therefore, if we do not consider this reverse causality, 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 (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

\(^{12}\) However, if industry-level availability of CVC at \( t_1 \) is forward-looking and correlated with innovation opportunities at \( t_2 \), then our exclusion restriction will be violated (Bertrand and Mullainathan 2003).

\(^{13}\) An alternative approach is to use the first-round financing date (at \( t=t_0 \) in Figure 1, rather than \( t=t_1 \)) to capture the CVC funding environment for all ventures regardless of whether they eventually received CVC funding. This approach has the benefit of maintaining consistency by reflecting the ventures’ funding environment during similar time frames. The results are qualitatively similar using this alternative approach.
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 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 ventures’ R&D intensity; rather, it indirectly affects them 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 effect of the instrument 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).

Methodologically, 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 et al. 2002; Stock and Yogo 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., CVC fund size may correlate with unobserved qualities of founders). We acknowledge that we cannot fully exclude the possibility of unobserved heterogeneity across ventures and, therefore, 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 1 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 of the VIF values are below 3, which is significantly below the suggested cut-off value, indicating that multicollinearity is not a problem in our study (Kennedy 2003).

Table 2 provides a series of regression results predicting ventures’ R&D intensity. Model 1 includes only our control variables, whereas Models 2-4 include our main variables of interest, CVC ownership and founder.
incumbency, separately and jointly in our base OLS regressions. 

H1 posits that CVC ownership is positively associated with the R&D intensity of an entrepreneurial venture. As Models 2 and 4 show, CVC ownership is positively associated with R&D intensity at the 1% significance level. H2 posits that founder incumbency is positively associated with R&D intensity of an entrepreneurial venture. Models 3 and 4 suggest that founder incumbency is positively associated with R&D intensity at the 1% level. Thus, the 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 Heckman and 2SLS estimation results.

First, we consider whether selection bias is present. That is, we investigate whether CVC-funded ventures began as more R&D intensive than IVC-only-funded ventures within our sample. Table 3 reports the first-stage estimation results (i.e., selection equation), and Model 5 of Table 2 reports the outcome equations, in which we correct for selection bias by including the inverse Mills ratio (λ: Lambda) calculated at the first stage. As shown, we obtain results that are consistent with our OLS regressions. In Model 5, CVC ownership remains positively associated with R&D intensity at the 1% significance level even after we correct for selection bias. However, λ is not statistically significant (p = 0.44), and a Wald test shows that the coefficients for CVC ownership in Model 4 and Model 5 (0.4475 vs. 0.4661) are not significantly different (Shaver 1998). Therefore, selection bias does not appear to be a concern in our sample.  

Next, we report the 2SLS estimation results that address reverse causality. That is, we attempt to tease out whether greater CVC ownership leads entrepreneurial ventures to invest more in R&D, as we hypothesize (H1), or whether more R&D-intensive ventures lead CVCs to retain greater ownership. In practice, the relationship may operate in both directions; however, our 2SLS approach allows us to identify the link between CVC ownership and R&D intensity without the concern of reverse causality. Models 6 and 7 present the results of the first and second stage of the 2SLS regression, respectively. 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 adjust for reverse causality. 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 more VC financing in later rounds. Thus, due to dilution, CVC ownership (%) in R&D-intensive ventures can decrease at the time of the IPO.

Because our 2SLS approach is free from reverse causality concerns (and selection bias is not present), we compute marginal effects using the results of Model 7 at the mean value of our explanatory variables. According to Model 7, 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 0.76%. Thus, our results are not only statistically significant but also economically significant—and realistic.

Our results are robust to a host of alternative specifications, including (1) using a dummy variable for CVC-funded ventures instead of the continuous CVC ownership variable, (2) using the logarithm of one plus R&D spending as the dependent variable and adding the logarithm of total firm assets on the right-hand side of the model as a control, (3) dropping all observations with R&D intensity equal to zero (n = 7), (4) using a Tobit model by treating all observations with R&D intensity equal to zero as censored data, (5) dropping an outlier (R&D intensity = 2.29), and (6) using normalized R&D intensity as the dependent variable.  

Table 4 reports our PSM analysis that tests H2. The total sample size is reduced (N=193+66=259) because we consider only observations within the common support. After matching, the only major difference between the two groups is whether the founder is an incumbent manager. According to Table 4, the average treatment effect (ATE) on

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14 We acknowledge that selection bias documented in previous studies could be a concern (e.g., Park and Steensma 2012). We note only that our sample selection scheme reduces concerns regarding selection bias in our setting, allowing us to identify the CVC effect without any selection bias concerns. In other words, conditional on going public, there is no systematic difference in R&D intensity between IVC-only-funded ventures and CVC-funded ventures.

15 The results are not reported here to save space; however, they are available from the authors upon request.

16 While we do not report the balancing test for all of our matching variables separately for the sake of brevity, our STATA output reports that the balancing property is satisfied after matching. Kernel density functions before and after matching are also available upon request.
the treated is positive and statistically significant at the 5% level, which suggests that having a founder-CEO or founder-CTO increases the R&D intensity of the focal venture by 8.4% relative to a venture that does not have a founder in such a position. Therefore, while addressing potential endogeneity concerns in our data, we find strong support for both H1 and H2.

H3 proposed that the positive relationship between CVC ownership and an entrepreneurial venture’s R&D intensity is stronger when the founder is an incumbent top manager due to knowledge spillover. In Table 5, Models 1 and 2 show a split sample analysis based on whether a firm’s founder is an incumbent top manager. For brevity, we report only the second stage results from our 2SLS regression in Models 1 and 2. In both models, CVC ownership is positive and statistically significant, and a Wald test comparing the two coefficients across models shows that the two coefficients are significantly different (p-value = 0.00). 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. In the next section, we present additional empirical results to tease out some of our key mechanisms.

Mechanisms
CVC-IVC tension and industry heterogeneity
Some of the mechanisms hypothesized in H1 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 magnitude 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, as VC ownership increases relative to CVC ownership, the positive CVC effect should be smaller in magnitude (relative to that in the BT sector) because resources may be allocated more to non-R&D activities such as marketing activities (e.g., user acquisition or promotion), as discussed in H1. Consistent with this view, Models 3 and 4 of Table 5 show 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 conflict differs across industries.

CVC investment and a venture's defensive mechanism
Katila et al. (2008) examine the ‘sharks’ dilemma, which occurs when ventures decide to ally with large corporations and to accept CVC investment because these sharks may misappropriate their technologies. The authors find that ventures form these relationships when the resources that CVC provide are needed and unique (e.g., financial and manufacturing resources) and when ventures have effective defense mechanisms to protect their own resources from potential misappropriation (e.g., patents). Their study shows that the venture, rather than the CVC, primarily makes the choice regarding CVC investment (i.e., ventures can always reject CVC funding in favor of VC funding; our interviews with entrepreneurs and investors corroborate this view), which diminishes the endogeneity concern regarding CVC firms choosing to invest more in ventures because they are more R&D intensive (i.e., reverse causality). Moreover, if the positive relationship between CVC and R&D intensity is magnified in the presence of tech-based defenses against misappropriation (which we measure using patents at the time of CVC funding), then CVC firms are actually shifting the venture’s R&D investment strategy because the ventures would still be confident that their R&D outputs would not be misappropriated (H1). Indeed, our data show that the positive relationship between CVC ownership and R&D intensity is magnified for ventures that had patents prior to CVC investment compared with those that did not.

17 We do not report 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. All results are available from the authors upon request. The results of Model 7 in Table 2 also suggest that having a founder-CEO or founder-CTO increases the R&D intensity of the focal venture by 7.42% relative to a venture that does not have a founder in such a position.

18 We test H3 using a split sample analysis rather than using an interaction term within a single 2SLS regression model with multiple instruments because we have only one instrumental variable.
Founder effect or founders’ technological background effect?

The founder effect we identify (H2) may be mainly driven by founders with strong technological backgrounds, which are common in technology-intensive industries. If, systematically, founders have a strong technological background but professional agent-managers do not, and this difference in background enables founder-managers to invest more in R&D, then the founder effect we identify 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 non-technical backgrounds (e.g., marketing or finance). To do so, we collect additional 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 re-running Model 7 of Table 2 yields results that are similar to our main results (Founder incumbency = 0.0737**). Thus, our founder effect holds even for founders with non-technical backgrounds, suggesting that entrepreneurial spirit and craftsmanship are important distinguishing traits of founder-managers, as hypothesized (H2).

CVC 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 investments provide active interaction and knowledge spillover is relatively 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 they describe their investment objectives and whether they emphasize a tight relationship with their corporate parent. In addition, we investigate whether the CVC firm’s physical address is identical to that of the corporate parent’s headquarter. 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 described the board member (i.e., whether she was an executive of 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 one 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, we verify that, among CVC-funded ventures (regardless of founder incumbency), ventures with a CVC investor on the venture’s board exhibit greater R&D intensity than those that do not (R&D intensity = 0.47 vs. 0.27; p-value = 0.00)20. This 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, we also verify 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 (R&D intensity: 0.43 vs. 0.30; p-value = 0.08). The result suggests that founders utilize more knowledge spillover utilized when they interact with tightly integrated CVC programs compared with more standalone CVC programs. This finding is consistent with the mechanism hypothesized in H3. Third, while Table 5 shows that the positive effect of CVC ownership on R&D intensity is greater when the venture is managed by founders, in general, our data show that having a CVC investor on the venture’s board does not make any significant difference in the CVC-founder interaction effect. That is, the 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 (R&D intensity = 0.38 vs. 0.35; p-value = 0.71). In comparison, when the founder is not incumbent, the mean R&D intensity is only 0.18 (i.e., 0.25 and 0.15 for CVC-funded ventures and IVC-only-funded ventures, respectively). Lastly, our data also show that the CVC–founder interaction effect becomes stronger if the

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19 In unreported robustness check analyses, we check whether ventures with ecosystem-based technologies (i.e., the nature of the business) are systematically more likely to be matched with corporate investors and examine whether this leads to any bias. We do not find any evidence to support this alternative explanation.

20 Because of the sample size and because we have only one instrumental variable, we present mean-comparison tests rather than using three-way interaction terms in a 2SLS regression framework.
founder has a strong technological background than if the founder does not (R&D intensity = 0.44 vs. 0.25; p-value = 0.01): strong technological background matters. We also find that CVC-funded ventures with founder-managers that do not have strong technological backgrounds display greater R&D intensity than CVC-funded ventures with professional agent-managers that do not have strong technological backgrounds (R&D intensity = 0.25 vs. 0.19; p-value = 0.08): strong entrepreneurial spirit matters. Therefore, these results suggest that founders can utilize knowledge spillover more effectively if they have a strong technological background. At the same time, both technological and non-technological knowledge may be involved in the CVC–founder interaction. More importantly, our data also indicate that the average patent count at the time of CVC funding does not significantly differ according to whether the founder was present (p-value = 0.79), suggesting that ventures with innovative founders are not more likely to attract CVC investment than other ventures.

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 that 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 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 startup assistance programs. During these meaningful contacts, entrepreneurial founders can identify more investment opportunities than professional managers. Our interviews with CVC investors and founders revealed much anecdotal evidence consistent with these hypothesized mechanisms.

**Extensions and robustness check**

**CVC effect in non-IPO ventures**

In our study, we use 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 tension is 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 stemming from analyzing a sample that includes only ventures that eventually go public. In other words, we further empirically investigate whether the ‘CVC effect’ identified in this study (H1) similarly applies to privately held ventures that could have gone public but did not. Obviously, some of the hypothesized mechanisms can be softened for non-IPO ventures (e.g., as the venture approaches an IPO event, the CVC–IVC tension will be lacking).

We note that many data restrictions when examining privately held ventures 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 measure of R&D outcome (i.e., innovation output) commonly used 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 (Diff-in-Diff) framework (with $r = 2.3$ years; 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, venture development stage at first funding year, etc., to replicate our original sample as closely as possible. Thus, we construct a sample of N=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, 2015;
Chemmanur et al. 2014), suggesting that the positive effect of CVC funding on R&D investment does not systematically differ between IPO and non-IPO ventures. However, as previously conjectured, IPO ventures appear to be more ‘successful’ because they produce more patents, on average, than non-IPO ventures.

In sum, while the above analysis is obviously less than ideal due to data limitations, our results and prior studies showing that CVC investors positively affect a venture’s innovation level regardless of its exit status (e.g., Chemmanur et al. 2014) suggest that our main results—CVC ownership of a venture is positively associated with the venture’s R&D intensity—likely apply to non-IPO CVC-backed ventures.

**Productivity of R&D expenditure**

Because greater CVC investment leads to both greater R&D intensity (input) and increased patents (output), as discussed above, the effect of CVC investment on the venture’s overall productivity of R&D expenditure remains ambiguous. Nonetheless, this is an important empirical question to test. Furthermore, founder-managers may better utilize knowledge spillover (as argued in H3) and affect the productivity of R&D expenditure in addition to increasing the level of R&D intensity, as shown. 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. 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 vs. 0.92; p-value = 0.00), suggesting that CVC-funded ventures enjoy greater productivity of R&D expenditure. However, we do not find any significant difference in the productivity between CVC-funded ventures with and without founders (1.88 vs. 1.54; p-value = 0.62).

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 display heterogeneity across sectors. For example, in the ICT sector, many ventures produce intermediate goods that have relatively shorter development cycles and are used in conjunction with the CVC parent company’s finished products. In this case, founders are more likely to utilize subtle knowledge 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 such as gene therapy, which may be radically different from existing products that large established firms provide, and customization is less likely. These products are typically finished products with relatively longer development cycles that rely more on the distribution, manufacturing, regulatory capabilities (e.g., FDA approval strategy), or industry knowledge of the CVC parent company rather than the CVC parent company’s 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 pre-existing innovation projects, because they know they can efficiently access the CVC parent company’s complementary assets for product 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 (or “patents” in our measure) for a long period of time, if ever (our measure of productivity covers only a 3-year window due to data limitations). 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). This result lends some support to our argument, although significantly larger sample sizes in these sub-categories would be ideal.

In sum, we believe that 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. 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**

Technology-based entrepreneurial ventures are subject to a host of external and internal forces that shape their activities and performance. Some of the major forces are the heterogeneity of (a) founders’ or top managers’

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21 Furthermore, we analyze data that include all VC/CVC-funded ventures, regardless of eventual exit status (IPO, bankrupt, private etc.), at the industry level, as done in the study by Kortum and Lerner (2000), by including industry-level CVC disbursement within a production function framework. We find that an increase in CVC disbursement is associated with an increase in patent output.
propensity and (b) investors’ identity. Moreover, these forces likely interact in subtle ways. In the context of entrepreneurial ventures, R&D investment strategy is an important aspect that is affected by these pressures. Thus, cash-strapped young entrepreneurial firms in technology-intensive industries must especially understand R&D investment strategy (Barker and Mueller 2002; Kor 2006) because R&D investment is both a significant source of product innovation and a strategic resource-allocation decision made by the governing body of the venture, which likely reflects the sharp conflict of interests among key stakeholders (e.g., priority of innovation vs. commercialization). In this study, we articulate the organizational mechanisms by which external (e.g., CVC, IVC) and internal factors (e.g., founders, professional agent-managers) shape a venture’s R&D investment strategy and find empirical support for those mechanisms. We find that CVC ownership and founder incumbency positively affect R&D investment in entrepreneurial firms and, more importantly, that the CVC ownership effect is amplified when the founder is an incumbent top manager because founders utilize knowledge spillover more effectively than professional agent-managers. 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.

It is worth noting, however, that our findings can be either value enhancing or value destroying depending on the idiosyncratic situation of the venture and some key assumptions. 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 myopic22, 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’ propensity for greater R&D investment would partially offset this downward bias and maximize a firm’s long-term value. Furthermore, knowledge created during the R&D process can have non-exclusive, non-rivalrous 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. Then, CVC firms’ and founders’ propensities toward more R&D investment can be socially desirable.

On the other hand, for young entrepreneurial firms, excessive focus on R&D rather than on building a stable operation more broadly can increase the risk of failure (Ries 2011). An over-investment 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 an R&D substitute 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 over-invest 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 over-investment 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. To date, most studies on CVC firms focus on the perspective of the corporate parent (e.g., Benson and Ziedonis 2009; Dushnitsky and Lenox 2005a; Wadhwa and Kolha 2006) and pay less attention to the consequences for the investee firms. These studies show that acquiring knowledge from entrepreneurial ventures is one of the primary strategic

22 In other words, 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 1992; O’Donoghue and Rabin 1999).
objectives of CVC investment (Dushnitsky and Lenox 2005a, b; Smith and Shah 2013) and thus emphasize the inherent conflict between CVCs and entrepreneurs (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 that founders more effectively take advantage of this spillover when interacting with CVCs because of their technological expertise, motivation, tacit knowledge, entrepreneurial spirit, longer planning horizon, and other characteristics stemming from their ‘ownership plus’ mentality. Thus, this study joins the literature on CVC firms from the investor’s perspective (e.g., Katila et al. 2008; Park and Steensma 2012) and broadly speaks to the significance of investor heterogeneity in the entrepreneurial finance literature (e.g., Alvarez-Garrido and Dushnitsky 2015; Paunke et al. 2015). Furthermore, our findings complement some recent studies that find that CVC-funded ventures tend to have superior innovation output (e.g., Alvarez-Garrido and Dushnitsky 2015; Chemmanur et al. 2014) by showing that this superior performance may be a result of the venture’s increased R&D intensity (thus, implications for a venture’s productivity and welfare remain ambiguous, as discussed above). We introduce novel mechanisms unidentified in prior studies such as the technology endorsement effect, CVC-founder interaction, knowledge spillover etc. to account for a venture’s increased R&D expenditure. 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 conflict (Berle and Means 1932; Jensen and Meckling 1976) dominates the corporate governance literature, there is a growing body of literature on principal-principal conflict that departs from the core assumptions of classical agency theory (e.g., Connolly 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 firms are additional contexts in which such principal-principal conflicts are severe. The board composition of entrepreneurial firms differs vastly from that of large established corporations (Baker and Gompers 2003), and the classical agency problems between shareholders and managers stemming from the separation of ownership and control prevalent in large established corporations are less severe or almost nonexistent in founder-led entrepreneurial firms (Wasserman 2003, 2006). Accordingly, we adopt a new perspective to elucidate R&D investment strategy in early-stage entrepreneurial firms because of the unique board and manager characteristics of the entrepreneurial firm context and, importantly, complement studies such as that of Kor (2006), which examines the effects of board and manager characteristics on R&D investment strategy in large publicly traded corporations.

Limitations and future research

Similar to all studies, this paper has some limitations. First, due to data limitations, we are not able to perform the desired in-depth analysis of non-IPOed 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 IPO. Thus, we cannot rule out all alternative explanations and establish a 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 is precisely measuring the theorized mechanisms underlying the effect of CVC in driving the R&D investment strategy 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 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 strategy. We hope our study can serve as a stepping-stone for advancing our understanding of the organizational dynamics in entrepreneurial firms.
References


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Rosenbaum, P.R., D.B. Rubin. 1983. The central role of the propensity score in observational studies for causal effects. Biometrika 70(1) 41-55.


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Table 1. Summary statistics and pairwise correlation matrix for all variables

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<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>Median</th>
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<th>min</th>
<th>max</th>
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<th>(2)</th>
<th>(3)</th>
<th>(4)</th>
<th>(5)</th>
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<td>(1) R&amp;D intensity</td>
<td>0.240</td>
<td>0.155</td>
<td>0.264</td>
<td>0.00</td>
<td>2.29</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>(2) CVC ownership</td>
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<td>0</td>
<td>0.087</td>
<td>0.00</td>
<td>0.57</td>
<td>0.192*</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
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<td>0.490</td>
<td>0.00</td>
<td>1.00</td>
<td>0.188*</td>
<td>0.009</td>
<td>1.00</td>
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<td></td>
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<tr>
<td>(4) Founder ownership</td>
<td>0.107</td>
<td>0.046</td>
<td>0.161</td>
<td>0.00</td>
<td>0.99</td>
<td>-0.041</td>
<td>-0.055</td>
<td>0.312*</td>
<td>1.00</td>
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</tr>
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<td>(5) VC ownership</td>
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<td>0.311</td>
<td>0.258</td>
<td>0.00</td>
<td>1.00</td>
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<td>-0.241*</td>
<td>-0.139*</td>
<td>-0.405*</td>
<td>1.00</td>
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<td>(6) Financial slack</td>
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<td>4.051</td>
<td>1.563</td>
<td>0.31</td>
<td>11.74</td>
<td>-0.227*</td>
<td>0.078</td>
<td>-0.002</td>
<td>0.127*</td>
<td>-0.024</td>
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<td>(7) Venture age</td>
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<td>7</td>
<td>3.588</td>
<td>2.00</td>
<td>20.00</td>
<td>-0.198*</td>
<td>0.026</td>
<td>-0.258*</td>
<td>0.080</td>
<td>-0.143*</td>
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<td>(8) Number of inside board members</td>
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<td>0.640</td>
<td>0.00</td>
<td>5.00</td>
<td>-0.076</td>
<td>-0.060</td>
<td>0.263*</td>
<td>0.273*</td>
<td>-0.122*</td>
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<tr>
<td>(9) Number of outside board members</td>
<td>5.727</td>
<td>6</td>
<td>1.561</td>
<td>1.00</td>
<td>12.00</td>
<td>0.087</td>
<td>0.095</td>
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<td>0.075</td>
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<td>0</td>
<td>0.493</td>
<td>0.00</td>
<td>1.00</td>
<td>-0.148*</td>
<td>-0.061</td>
<td>0.140*</td>
<td>0.184*</td>
<td>-0.170*</td>
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<td>(11) Number of fundraising rounds</td>
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<td>6</td>
<td>2.939</td>
<td>1.00</td>
<td>15.00</td>
<td>0.222*</td>
<td>0.081</td>
<td>0.003</td>
<td>-0.203*</td>
<td>0.121*</td>
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<td>(12) Total invested amount</td>
<td>11.257</td>
<td>11.291</td>
<td>1.103</td>
<td>4.94</td>
<td>15.35</td>
<td>0.085</td>
<td>0.163*</td>
<td>-0.051</td>
<td>-0.292*</td>
<td>0.110*</td>
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<td>(13) Number of total investors</td>
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<td>9</td>
<td>5.833</td>
<td>1.00</td>
<td>31.00</td>
<td>0.226*</td>
<td>0.164*</td>
<td>0.004</td>
<td>-0.321*</td>
<td>-0.001</td>
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<td>(14) Availability of CVC (SM)</td>
<td>4476.22</td>
<td>2619.18</td>
<td>4236.58</td>
<td>470.33</td>
<td>15196.72</td>
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<td>-0.006</td>
<td>-0.118*</td>
<td>-0.066</td>
<td>0.004</td>
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<td>(15) CVC fund size (SM)</td>
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<td>3.819</td>
<td>0.00</td>
<td>35.83</td>
<td>0.009</td>
<td>0.348*</td>
<td>0.075</td>
<td>0.000</td>
<td>-0.132*</td>
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<table>
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<tr>
<th>Variables</th>
<th>(6)</th>
<th>(7)</th>
<th>(8)</th>
<th>(9)</th>
<th>(10)</th>
<th>(11)</th>
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<td>(7) Venture age</td>
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<td></td>
<td></td>
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<td>(8) Number of inside board members</td>
<td>-0.016</td>
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<td>(9) Number of outside board members</td>
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<td>-0.284*</td>
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<td>(10) CEO-chairman duality</td>
<td>-0.018</td>
<td>0.056</td>
<td>0.179*</td>
<td>-0.132*</td>
<td>1.000</td>
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<tr>
<td>(11) Number of fundraising rounds</td>
<td>-0.004</td>
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<td>-0.157*</td>
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<td>(12) Total invested amount</td>
<td>0.172*</td>
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<td>-0.152*</td>
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<td>0.484*</td>
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<td>(13) Number of total investors</td>
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<td>0.022</td>
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<td>0.345*</td>
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<td>0.196*</td>
<td>0.262*</td>
<td>-0.018</td>
</tr>
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N = 319, * significant at the 5% level or higher
### Table 2. CVC ownership, founder incumbency, and R&D intensity of IPO firms: main results

<table>
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<th>IV - 2SLS</th>
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<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
</tr>
<tr>
<td>Founder ownership</td>
<td>0.1220</td>
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<tr>
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<td>(0.0457)</td>
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<td>(0.0808)</td>
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<td>(0.0559)</td>
<td>(0.0557)</td>
<td>(0.0541)</td>
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<td>-0.0381***</td>
<td>-0.0355***</td>
<td>-0.0320***</td>
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<td>(0.0126)</td>
<td>(0.0126)</td>
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<td>Venture age</td>
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<td>(0.0028)</td>
<td>(0.0030)</td>
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<td>-0.0261</td>
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<td>(0.0202)</td>
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<td>-0.0035</td>
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<td>(0.0095)</td>
<td>(0.0097)</td>
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<td>(0.0247)</td>
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<td>(0.0240)</td>
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<td>(0.0001)</td>
<td>(0.0009)</td>
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<td>-0.0176</td>
<td>-0.0136</td>
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<td>(0.0124)</td>
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<td>(0.0029)</td>
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<td>CVC ownership</td>
<td>0.4554***</td>
<td>0.4473***</td>
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<tr>
<td></td>
<td>(0.1352)</td>
<td>(0.1328)</td>
<td>(0.1574)</td>
</tr>
<tr>
<td>Founder incumbency</td>
<td>0.0769**</td>
<td>0.0753**</td>
<td>0.0633*</td>
</tr>
<tr>
<td></td>
<td>(0.0308)</td>
<td>(0.0306)</td>
<td>(0.0337)</td>
</tr>
<tr>
<td>LAMBDA ((\lambda))</td>
<td>-0.0481</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.0629)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CVC fund size ($M)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.5442***</td>
<td>0.5446***</td>
<td>0.5127***</td>
</tr>
<tr>
<td></td>
<td>(0.1861)</td>
<td>(0.1835)</td>
<td>(0.1810)</td>
</tr>
<tr>
<td>State dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>319</td>
<td>319</td>
<td>319</td>
</tr>
<tr>
<td>F-stat/Walh Chi2</td>
<td>7.39***</td>
<td>8.37***</td>
<td>6.93***</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.3279</td>
<td>0.3453</td>
<td>0.3431</td>
</tr>
</tbody>
</table>

Heteroskedasticity-robust standard errors clustered at the lead investor level are presented in parentheses. *** p < 0.001, ** p < 0.01, * p < 0.05.
Table 3. Heckman selection model: first-stage regression results

<table>
<thead>
<tr>
<th>Variables</th>
<th>Heckman 1st stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability of CVC (SM)</td>
<td>0.0001***</td>
</tr>
<tr>
<td></td>
<td>(0.0000)</td>
</tr>
<tr>
<td>Founder present</td>
<td>0.0847</td>
</tr>
<tr>
<td></td>
<td>(0.1776)</td>
</tr>
<tr>
<td>Number of total investors at first round</td>
<td>0.0772</td>
</tr>
<tr>
<td></td>
<td>(0.0519)</td>
</tr>
<tr>
<td>Total invested amount at first round</td>
<td>-0.0000</td>
</tr>
<tr>
<td></td>
<td>(0.0000)</td>
</tr>
<tr>
<td>Venture age at first round</td>
<td>-0.0351</td>
</tr>
<tr>
<td></td>
<td>(0.0357)</td>
</tr>
<tr>
<td>Seed stage at first round (=1 if startup was at the seed stage at 1st round)</td>
<td>-0.4377</td>
</tr>
<tr>
<td></td>
<td>(0.7281)</td>
</tr>
<tr>
<td>Early stage at first round (=1 if startup was at the early stage at 1st round)</td>
<td>-0.6524</td>
</tr>
<tr>
<td></td>
<td>(0.7147)</td>
</tr>
<tr>
<td>Expansion stage at first round (=1 if startup was at the expansion stage at 1st round)</td>
<td>-0.6160</td>
</tr>
<tr>
<td></td>
<td>(0.7448)</td>
</tr>
<tr>
<td>Later stage at first round (=1 if startup was at the later stage at 1st round)</td>
<td>-0.1981</td>
</tr>
<tr>
<td></td>
<td>(0.9026)</td>
</tr>
<tr>
<td>Acquisition stage at first round (=1 if startup was at the acquisition stage at 1st round)</td>
<td>-1.6385**</td>
</tr>
<tr>
<td></td>
<td>(0.8438)</td>
</tr>
<tr>
<td>Constant</td>
<td>5.2757***</td>
</tr>
<tr>
<td></td>
<td>(1.0435)</td>
</tr>
<tr>
<td>First round year fixed effect</td>
<td>Yes</td>
</tr>
<tr>
<td>State dummies</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry dummies</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>312</td>
</tr>
</tbody>
</table>

First stage of Heckman's two-step efficient estimation. Conventional standard errors are presented in parentheses. *** p < 0.01, ** p < 0.05, * p < 0.1
Table 4. Propensity score matching (H2): Average treatment effect on the treated (ATT) estimation with nearest neighbor matching method

<table>
<thead>
<tr>
<th>treatment group</th>
<th>(matched) control group</th>
<th>ATT</th>
<th>t-stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Founder incumbency = 1</td>
<td>Founder incumbency = 0</td>
<td>0.084**</td>
<td>2.490</td>
</tr>
<tr>
<td>(N=193)</td>
<td>(N=66)</td>
<td>(0.036)</td>
<td></td>
</tr>
</tbody>
</table>

Note: 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.

Table 5. Testing H3 using split-sample analysis and industry heterogeneity

<table>
<thead>
<tr>
<th>Variables</th>
<th>H3: Founder Incumbency = 1</th>
<th>H3: Founder Incumbency = 0</th>
<th>ICT sector</th>
<th>BT sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVC ownership</td>
<td>1.3431**</td>
<td>0.3441*</td>
<td>0.7218*</td>
<td>1.3084***</td>
</tr>
<tr>
<td></td>
<td>(0.6398)</td>
<td>(0.2130)</td>
<td>(0.4508)</td>
<td>(0.5069)</td>
</tr>
<tr>
<td>Controls</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>State dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry dummies</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Observations</td>
<td>193</td>
<td>126</td>
<td>174</td>
<td>145</td>
</tr>
<tr>
<td>F-stat/Wald Chi2</td>
<td>98.99***</td>
<td>97.90***</td>
<td>62.58***</td>
<td>97.53***</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.3396</td>
<td>0.4574</td>
<td>0.1770</td>
<td>0.3360</td>
</tr>
</tbody>
</table>

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

Table 6. R&D productivity comparison between ICT and BT sectors

<table>
<thead>
<tr>
<th>CVC-funded ventures</th>
<th>Average patent count per thousand dollars of R&amp;D expenditure</th>
<th>Number of ventures</th>
<th>Mean comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICT sector</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Founder incumbent = Yes</td>
<td>3.64</td>
<td>22</td>
<td>1.64 [t-value]</td>
</tr>
<tr>
<td>Founder incumbent = No</td>
<td>1.42</td>
<td>19</td>
<td>(0.11) [p-value]</td>
</tr>
<tr>
<td>BT sector</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Founder incumbent = Yes</td>
<td>0.9</td>
<td>40</td>
<td>1.61 [t-value]</td>
</tr>
<tr>
<td>Founder incumbent = No</td>
<td>1.68</td>
<td>18</td>
<td>(0.11) [p-value]</td>
</tr>
</tbody>
</table>

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Figure 1. Timeline of relevant variables used in the Heckman two-stage estimation procedure

Figure 2. R&D output trend in CVC-funded ventures vs. IVC-only-funded ventures for IPOed and non-IPOed ventures.