© Academy of Management Journal
2006, Vol. 49, No. 4, 1–000.

KNOWLEDGE CREATION THROUGH EXTERNAL VENTURING: EVIDENCE FROM THE TELECOMMUNICATIONS EQUIPMENT MANUFACTURING INDUSTRY

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Investment in entrepreneurial ventures has gained recent popularity as a means for established firms to learn about new technologies and markets. However, the link between such corporate venture capital (CVC) investments and innovation outcomes has not been examined in detail. Using panel data from corporate investors in telecommunications equipment manufacturing, we investigated the conditions under which CVC investments affect knowledge creation for corporate investors. We found that, when investor involvement is low, number of CVC investments has an inverted U-shaped relationship with innovation performance. However, when investor involvement is high, the relationship reverses, and an increase in investments boosts innovation.

In technology-intensive industries, the pace and complexity of technological change create many uncertainties for organizations, and these, in turn, force organizations to innovate continuously to be competitive. But often organizations do not possess the knowledge required to produce innovations and are limited in their ability to produce knowledge purely through internal R&D investments (Hagedoorn, 1993). To accumulate the necessary knowledge, many organizations turn to external activities such as alliances, joint ventures, mergers and acquisitions, and corporate venture capital (CVC) investments (Schildt, Maula, & Keil, 2005). However, the choice of any one of these strategies, as well as their implementation, can have serious implications for firm-level innovation and knowledge creation. In this study, we examine the impact of CVC investments, one mode of external corporate entrepreneurship, on knowledge creation.

CVC investments are defined as external equity investments made by established firms in privately held entrepreneurial start-ups (Gompers & Lerner, 1998). In the mid-1990s, CVC activities by firms picked up significantly in the United States, both as a percentage of all venture capital investments made and as the number of companies financed by corporate investors, according to a 2004 report from the National Venture Capital Association. Also, global firms such as Xerox, Lucent, and Nokia have formalized their CVC activities by setting up specific programs. These firms have often cited strategic benefits, such as learning and new-knowledge creation, as their predominant motives for CVC investing. Although the magnitude of CVC investments generally goes through substantial swings, swings that tend to be more pronounced than overall VC investment (a sharp decline in corporate venture investing since 2000 offers evidence), several corporations have shown continued commitment to such activities (Chesbrough, 2002).

Although past research identified numerous strategic benefits of CVC investments, such as exposure to new markets and technologies, identification of acquisition targets, and market extension possibilities (Siegel, Siegel, & MacMillan, 1988; Sykes, 1990), recent research has emphasized the role of CVC investments as conduits for knowledge spillovers from innovative start-ups to corporate investors. For example, Maula, Keil, and Zahra (2003) showed that as corporations invest in start-ups, they enhance their ability to recognize potentially destructive technological discontinuities in the marketplace faster than rivals who fail to make such investments. To these authors, CVC investment represented a strategic approach that incumbents employ to avoid being blindsided by techno-

We thank the guest coeditor, Anil Gupta, two anonymous reviewers, Sandip Basu, Tom Lee, Corey Phelps, MB Sarkar, Kevin Steensma, Christopher Tucci, and Mina Yoo for their valuable comments and suggestions on this and earlier versions of the paper. We also thank Corey Phelps and Shiva Rajgopal for methodological suggestions that helped improve the quality of our analyses.

logical change. Keil, Zahra, and Maula (2004) argued that CVC investments can result in both exploitative and explorative learning and that the type of learning an investor firm gains depends upon the characteristics of the start-ups it invests in and the formal structure of its CVC program. In a similar vein, Dushnitsky and Lenox (2005) showed a direct, positive relationship between CVC investments and firm innovation and demonstrated that industry-level (e.g., intellectual property regimes) and firm-level (e.g., investor absorptive capacity) factors moderated this relationship. In contrast to the above studies, Schildt and colleagues (2005) showed that learning from CVC investments has weaker efficacy than learning from other modes of external corporate venturing (i.e., acquisition and joint ventures).

The research reviewed above asserts that start-up firms represent an important opportunity for corporate investors to explore new ideas and knowledge. Empirical findings complement these theoretical assertions by unequivocally illustrating innovation-related benefits that result from CVC investments (Dushnitsky & Lenox, 2005), although their efficacy is often less pronounced when these investments are compared to other modes of external venturing (Schildt et al., 2005). However, no earlier study has addressed the potential costs of CVC investments and the potential limits to innovation for investor firms resulting from increased CVC activity. Specifically, the earlier studies have not explored factors that may increase the benefits and decrease the costs associated with this approach to innovation via corporate entrepreneurship.

The goal of this study was to provide a stronger theoretical basis for assessing such costs and to examine their implications for firm-level innovation. We focused on two research questions: What are the limits to knowledge creation from CVC investments? And when are these limits likely to manifest? Recognizing such limits is important because it would help researchers better understand why many corporate investors report dissatisfaction with CVC investments, despite the touted strategic benefits. Our premise was that the extent to which corporate investors learn from such investments varies. Hence, we identified and tested externally and internally oriented capabilities that affect corporate investors' ability to leverage access to sources of knowledge via CVC investments. Identifying such factors can explain heterogeneity in exploration outcomes, a question of importance to researchers in this domain.

We tested our proposed hypotheses using longitudinal data on 36 firms in the telecommunications equipment manufacturing industry during the period 1989–99. Our results indicate that, ceteris paribus, there is an optimum point beyond which the contribution of CVC investments to investor knowledge creation declines. Our results also suggested that when a corporate investor is highly involved with portfolio firms, it may be possible to reverse this decline. Specifically, we found that greater involvement with portfolio firms has a positive effect on the inverted U-shaped relationship between corporate venture capital investment and investors' knowledge creation. No such effect was found for investors' technological knowledge diversity.

THEORY AND HYPOTHESES

Exploration, defined as a process of search, variation, experimentation, and discovery (March, 1991), is closely aligned with distant search, which generates recombinations of new, unfamiliar knowledge with existing knowledge elements (Nelson & Winter, 1982). Although exploration and distant search are extremely important for organizational reconfiguration and renewal (Stuart & Podolny, 1996), both processes are often characterized by substantial costs, uncertainty, and risk. In practice, the dynamics of established organizations tend to drive out exploration activities altogether. Established organizations are under pressure to increase their frequency of experimentation and exploration as well as improve their rate of success with such activities to avoid falling into "learning traps" (Levinthal & March, 1993). Moreover, since firms are endowed with different capability sets and vary in their perceptions about the importance of opportunities available in their external environments, their success in achieving these goals is likely to show a great deal of variance.

We employ the search and exploration literature to discuss CVC investments' effect on innovation by conceptualizing CVC investment as an exploratory process through which firms attempt to acquire new capabilities. Firms use CVC investments to *explore,* or search, in their external environments for new opportunities and for new vistas of knowledge of strategic import (Keil, 2004). By ensuring an equity relationship with start-ups, corporate investors can potentially access new knowledge that would not otherwise be available. To realize the inherent value creation potential of this external knowledge, organizations must be able to recognize its useful components (Zahra & George, 2002), and they must deliberately act to capture this knowledge (Argote, 1999). Although the effect of CVC investments on knowledge acquisition has received little attention in the search literature, the difficulties inherent in distant search (Cyert &

March, 1963; Nelson & Winter, 1982) and the compensating mechanisms suggested in this literature provide a useful theoretical frame for appreciating and testing the benefits and limits of CVC investments as facilitators of knowledge.

CVC Investments and Knowledge Creation

It has been argued that CVC investment activity facilitates learning (Dushnitsky & Lenox, 2005). Before investing, corporations generally undertake extensive due diligence activities related to proposed ventures and whet accompanying details such as business plans, technology resources, proposed products, and market prospects. This process provides a firm with a unique opportunity to learn about all aspects of a venture before making a capital commitment (Dushnitsky & Lenox, 2005). Following investment, the firm may institute various mechanisms for interacting with the venture and for learning from it.

Access to new external knowledge can influence knowledge creation within investor firms. First, new information can help firms address established problems using a new approach or an approach that combines the old and the new (Ahuja & Katila, 2001). Investor firms may use new information to support, complement, or augment their internal R&D capabilities, exploit it to enter new markets or introduce new products earlier than competitors who lack access to new external knowledge (Chesbrough & Tucci, 2003; Maula et al., 2003), and improve existing products by adding new features and functionality (Keil et al., 2004). Second, access to new information improves the absorptive capacity (Cohen & Levinthal, 1990) of the investing firms and creates a basis for their future assimilation of additional external knowledge (Ahuja & Katila, 2001). In fact, empirical evidence shows that an increase in CVC investment is positively associated with increased future innovation (Dushnitsky & Lenox, 2005).

However, these findings about corporate venture capital investment's effects on knowledge creation also raise the issue of whether potential costs to innovation are associated with CVC investment. Managers may eventually face constraints in garnering greater knowledge creation returns by simply increasing CVC investments. These constraints involve diminishing and negative rates of knowledge creation with increased CVC investments. In other words, increasing the number of portfolio investments increases the probability that each additional portfolio firm makes a lower marginal contribution to the knowledge base of the corporate investor (Deeds & Hill, 1996), and this relationship may even turn negative at some point. Diminishing and negative returns to CVC investments arise because managers of CVC programs are "boundedly rational" (March & Simon, 1958). More importantly, they also operate under resource constraints, because typically CVC activities in large corporations receive limited organizational resources to manage the process (Keil et al, 2004). Under these conditions, too many CVC investments may confront their managers with information overload during the pre- and postinvestment stages and overstretch the managers' available resources for two reasons.

First, a large number of CVC investments can strain the cognitive capabilities of the managers and adversely affect their ability to select firms in which to invest. Venture assessment is a complex process that involves gauging the potential of an emerging technology. The sheer volume of information about the myriad technologies being developed outside their organization and the array of potentially promising entrepreneurial ventures can be overwhelming for managers of CVC programs. Furthermore, the complexity of the selection process itself can prevent managers from either absorbing important information presented to them or processing all the information in a timely manner.[1] Therefore, investors may end up selecting poor-quality ventures, which may subsequently fail to deliver the expected benefits.

Second, postinvestment, an investor organization needs to monitor the progress of its portfolio firms and nurture and cultivate them. Any knowledge gained from portfolio firms then has to be absorbed and applied within the investor to be beneficial. Monitoring new ventures is likely to strain the cognitive capacities of the managers of CVC programs. Absorption and use of new technological knowledge imposes further costs in the form of increased demand for the already limited cognitive and administrative resources available to the managers, scientists, and engineers in the investing organization. Thus, resource constraints and information overload inhibit a corporation's ability to manage a large portfolio of start-ups effectively (Keil et al., 2004). The drawbacks of an exploratory search, well documented in the literature, include the inability to process and interpret the amount of information generated by excessive exploration, which then poses a challenge to the learning process (Gavetti & Levinthal, 2000).

Taken together, these arguments suggest that, be-

[1] We are thankful to an anonymous reviewer for this suggestion.

yond a critical point, the relationship between number of CVC investments and rate of investor knowledge creation is characterized by diminishing as well as negative returns. Thus, we propose the following hypothesis:

Hypothesis 1. The rate of knowledge creation in investor firms has a curvilinear (inverted U-shaped) relationship with the number of corporate venture capital investments.

Although the search for and selection of portfolio firms to invest in represent a firm's exploratory strategy, they provide corporate investors only with an *opportunity* to learn. For the opportunity to be *realized,* corporate investors need mechanisms of knowledge transfer, as well as the ability to assimilate the inbound information effectively so that they can derive beneficial knowledge from it. We therefore consider involvement and technological knowledge attributes, which represent corporate investors' externally and internally oriented capabilities for pursuing exploration in the context of CVC investments.

Involvement with Portfolio Firms

If established firms are to learn from their portfolio firms, equity relationships alone may be insufficient. For absorbing and using potential new knowledge, corporate investors need to ensure that information from their portfolio firms reaches business units equipped to make sense of it. Doing so is particularly useful if the knowledge to be acquired is tacit (Kogut & Zander, 1992) or complex, since tacit and complex elements of knowledge are hard to access through mere scrutiny of the business plans and patent portfolios of new ventures.[2] Past research on CVC investments alludes to one activity that may facilitate knowledge transfer but has not explicitly tested it. This activity is corporate investors' degree of involvement with their portfolio firms (Dushnitsky & Lenox, 2005; Keil et al., 2004). Involvement refers to the extent to which corporate investors build relationships with their portfolio firms that go beyond just providing equity capital. Such alliances can act as conduits for the flow and integration of knowledge. Greater involvement with external entities not only uses the capabilities and skills of the employees of the corporate investors, but also refines and augments these skills.

In practice, corporate investors often establish interaction mechanisms such as joint R&D activities and other types of alliances to ensure greater resource sharing between themselves and their investee firms (Lane & Lubatkin, 1998). For example, a number of portfolio firms that received financing from Motorola Ventures reported active involvement with Motorola's business units (Keil, 2004). Forming such alliances allows corporate investors to benefit from the information as well as the know-how residing in their portfolio firms. In alliances, the interaction takes place at the level of R&D, marketing, and other personnel in business units and divisions of the corporate investor and their start-up firms. Alliances are thus able to provide corporate investors with greater access to knowledge spillovers than passive equity investments alone. Moreover, corporate investors learn by doing and attain resource-sharing benefits by combining their own knowledge, skills, and assets with those of the portfolio firms. The use of alliances to leverage preferential access to external sources of new knowledge has been recognized as an explorative capability (Koza & Lewin, 1998; Rothaermel & Deeds, 2004).

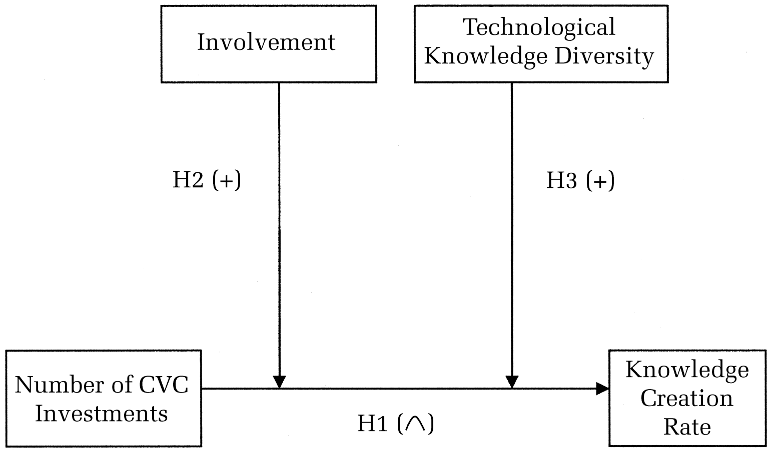
Corporate investors also interact with their portfolio firms through board membership in these firms (Dushnitsky & Lenox, 2005; Zahra, Ireland, & Hitt, 2000). Participation as voting board members or as members with observer rights ensures that investor firms are kept informed about the technology of new ventures as they evolve, given that board members have contact with the new venture's technical experts (Pisano, 1989). Thus, board membership provides another channel through which new information and ideas from portfolio firms can reach a corporate investor.

When the relationship between a firm's number of CVC investments and rate of knowledge creation is positive, greater involvement further enhances investor learning from portfolio firms and their subsequent rates of knowledge creation. Earlier we posited that with an increase in the number of CVC investments, the relationship between number of CVC investments and rate of knowledge creation turns negative, but greater involvement by the investor corporation can mitigate the information overload underlying such a change in direction. This can happen in two ways.

First, channeling information to business units so that the incoming knowledge is more efficiently absorbed and used distributes the responsibility of managing relationships with portfolio firms to other business-unit managers. Interaction between business units of a corporate investor and its portfolio firms helps the corporation understand the relevance and the complementarities of the new-

[2] We are thankful to an anonymous reviewer for this suggestion.

FIGURE 1
Proposed Theoretical Model



venture technology to its existing capabilities. Second, strong interaction among scientists, engineers, and other personnel of business units of the corporate investor and portfolio firms is important, especially when the new knowledge sought by the corporate investor is tacit or systemic. Tacit knowledge is abstract and is more difficult to transfer without active involvement between the student and teacher. Highly embedded relationships between organizations allow for richer communication, which in turn results in feedback mechanisms, proper interpretation of procedures, and accurate and effective transfer of tacit knowledge (Dhanaraj, Lyles, Steensma, & Tihanyi, 2004). All of these factors may generate new knowledge by uncovering hidden or nonobvious connections or identifying new connections between old information and new sources of information. Thus, we propose the following:

> *Hypothesis 2. Active involvement in investee firms positively moderates the relationship between firms' number of corporate venture capital investments and knowledge creation.*

Technological Knowledge Diversity

A firm's existing technological knowledge and its application to new opportunities and ideas in its environment (Keil, 2004) can set the stage for producing new technologies, products, and processes (Ahuja, 2000; Dushnitsky & Lenox, 2005). Hence, the other factor that can mitigate the negative effects or costs of increasing CVC investment involves knowledge attributes of the investor firm. The fact that learning is often dependent upon the prior knowledge stocks of firms raises the question as to whether certain attributes of prior knowledge stocks are important for learning to take place.

Prior literature on search has emphasized that firms seeking to reconfigure their knowledge must move beyond local search and span technological as well as organizational boundaries (Rosenkopf & Nerkar, 2001). However, little is known about how the nature of a corporate investor's knowledge facilitates or impedes its organization-spanning activities, such as CVC investments. Given the emphasis on variety as a precursor for potential recombinations, we explore the role of knowledge *breadth,* or diversity of prior knowledge, in future learning. Specifically, we focus on technological knowledge diversity as an important and untested moderator of the relationship between CVC investments and knowledge creation.

Two key arguments underlying the search explanations for the role of technological knowledge diversity in exploring and using external knowledge include the following:[3] First, sourcing previously unconnected pieces of information can be useful if these pieces are combined into new information or knowledge. The number of CVC investments made by a corporation is directly proportional to the probability that this corporate investor is exposed to different and possibly unconnected knowledge emanating from its portfolio firms. In such a case, the heterogeneity (or diversity or breadth) of technological knowledge within the investor firm increases the potential for absorption of information from multiple knowledge arenas. It also increases the potential for new combinations of knowledge

[3] We are thankful to an anonymous reviewer for this suggestion.

by bringing together distinct knowledge areas from internal and external sources. Since prior knowledge consists of simple pieces of information that become valuable in specific contexts (Winter, 1987), the implication is that a corporate investor exposed to new contexts outside its firm can develop new meanings and uses for its existing knowledge. Second, prior knowledge breadth can encourage a diversity of stimuli within the investor firm, enabling less rigid thought patterns so that more novel combination are generated. If an organization's knowledge base is narrow, its core capabilities are likely to evolve into core rigidities (Leonard-Barton, 1992). A broader knowledge base provides the firm with increased flexibility and adaptability to environmental changes (Volberda, 1996). In other words, knowledge diversity engenders a fluid mind-set conducive to new idea generation and innovation. Evidence from studying new product development shows that a firm's ability to integrate knowledge from different streams is positively related to a broad base of existing knowledge (Bierly & Chakrabarti, 1996).

The above two arguments suggest that a more diverse technological knowledge base will enhance an already positive relationship between number of CVC investments and the rate of knowledge creation. Even when this relationship turns negative, investor firms with more diverse technological knowledge bases are better able to evaluate and absorb incoming knowledge from their investments in young entrepreneurial firms and subsequently improve their innovative performance. Thus, technological knowledge diversity plays an important role in whether a corporate investor is able to maximize learning from external sources to create new knowledge. We offer the following hypothesis:

Hypothesis 3. Corporate investors' technological knowledge diversity will positively moderate the relationship between the number of corporate venture capital investments and knowledge creation.

F1 Figure 1 captures the framework developed in the above hypotheses.

METHODS

Research Setting and Sample

We focused on the telecommunications equipment manufacturing industry, which has undergone restructuring because of growing competition, technological change, and deregulation (Olley & Pakes, 1996). Deregulation has shifted the bases of competitive advantage toward achieving rapid and radical innovations (Phelps, 2003). Additionally, the pace of technological change in the industry and its convergence with microelectronics and computing sectors has resulted in some important trends. First, technological convergence has made the innovation process and nature of R&D in this industry much more systemic, and this has increased product complexity at the firm level (Pisano, Russo, & Teece, 1988). Second, the convergence with the microelectronics and computing sectors and increased competition have forced firms to participate in the demand as well as the supply side of CVC investments to keep abreast of changes and to track and access technologies and innovations.[4] Finally, firms in this industry routinely and systematically patent their inventions to protect intellectual property (Levin, Klevorick, Nelson, & Winter, 1987). Since we used patent data to measure the knowledge creation rate, firms in this industry provided an excellent context for this study.

We defined the telecommunications equipment manufacturing industry as including all types of network telecommunications and customer premises equipment and followed recent studies (i.e., Phelps, 2003) in using Standard Industrial Classification (SIC) codes 3661 (telephone and telegraph apparatus), 3663 (radio and TV communications equipment), and 3669 (communications equipment, not elsewhere classified) to assemble our sample of firms.

To construct our sample of public firms that had invested capital in private firms either directly or through their own venture funds, we drew on VentureXpert, the official database of the National Venture Capital Association (NVCA), which maintains a list of corporate investors at the fund level. Using this list of corporate funds, we searched extensively by fund name on Google and in online databases like Lexis-Nexis and Factiva to assign each corporate fund to its corporate parent. We then selected investor firms that represented the telecommunications equipment manufacturing industry.

We focused on the time period from 1989 to 1999. Our final sample consisted of 36 corporate entities that invested VC funds at least once in

[4] Of all the funds invested by venture capitalists in 1999, 16 percent ($13.1 billion) went to new ventures in the telecommunications sector. On the supply side, in 1999, telecom equipment manufacturers undertook 153 VC deals with start-ups, or 12 percent of all deals that corporate funds took part in, according to a 2004 report from the National Venture Capital Association.

start-ups during this period. The final panel, which consisted of 383 firm-year observations, was unbalanced because some firms underwent dissolution, acquisition, or mergers.

Measures

Dependent variable. The rate of knowledge creation, our dependent variable, was operationalized by the annual count of *successful* patent applications for firm i in year t. Prior studies (Ahuja, 2000; Ahuja & Katila, 2001; Sorensen & Stuart, 2000) have used patenting as a proxy for innovation rate. We used application date (the date when a firm files a patent application) to assign a granted patent to any firm in a given year because, compared to other dates, application date more proximally reflects the actual time of knowledge creation in the firm (Griliches, 1990).

To construct our measure of the rate of knowledge creation, we used data from Delphion, a patent database that provides detailed information on patents granted by the U.S. Patents and Trademarks Office (USPTO) since 1975. To maintain consistency, reliability, and comparability of patents, we used patents granted in the United States.

We used *Who Owns Whom* and the *Directory of Corporate Affiliations* to construct corporate family trees to appropriately identify the patents that were granted to subsidiaries of our sample firms. After identifying all subsidiaries of a firm in any given year, we aggregated the patents assigned to these subsidiaries in that year to the parent firm in the sample.

Independent variables. The number of CVC investments for each firm in the sample was a count of the total number of unique start-ups invested in by firm i in year $t - 1$. If a firm did not make any investments in a given year, a value of 0 was assigned.

To measure the degree of a corporate investor's involvement with its portfolio firms, we focused on (1) the number of alliances formed in a year between the corporate investor and a portfolio firm at the time of, or shortly after, the equity investment, and (2) the number of instances in which the corporate investor took seats on the board of directors of a portfolio firm. To compile these data, we conducted comprehensive searches by firm names and relevant keywords in Factiva and Lexis-Nexis. Our definition of alliances includes all types, including those involving joint R&D, codevelopment, manufacturing, and marketing. This measure was the sum of all alliances with portfolio firms in a year plus the number of times the investor filled seats on portfolio firms' boards divided by the investor's total number of CVC investments in that year. To check the robustness of our measures, we also used the ratio of alliances to investments and the ratio of board seats to investments as alternative measures of involvement.

We measured the technological knowledge diversity of a corporate investor by calculating the inverse concentration ratio of the distribution of a firm's patents over the primary technology classes to which they had been assigned (Nerkar, 2003; Silverman, 1999). This measure reflects the distribution of the corporate investor's patents across technology classes over four years ($t - 1$ to $t - 4$) prior to observation of the dependent variable. Specifically, the calculation was this: $\textit{technological knowledge diversity}_{i(t\,-\,1\text{ to }t\,-\,4)} = \Sigma P_j \times \ln\left(\frac{1}{p_j}\right)$, where P_j was the ratio of patents filed in patent class j, and $\frac{1}{P_j}$ was the weight for patent class j. This approach was similar to use of the entropy measure (Palepu, 1985), which is widespread in prior research, and a larger value of this measure represents greater diversity.

Control variables. To control for firm- and industry-level factors that might influence a firm's rate of knowledge creation, we included several control variables. Since a firm's stock of patents has been used to characterize its technological competence (Patel & Pavitt, 1997), we used it to represent a firm's ability to learn from external sources of knowledge (Henderson & Cockburn, 1996), its absorptive capacity (Cohen & Levinthal, 1990), and its ability to produce radical innovations. The prior patent stock of firm i was measured as the number of patents attributable to it in the four years prior to its entry into our sample.

Because prior joint ventures, alliances, and mergers and acquisitions (Ahuja & Katila, 2001) can affect knowledge creation, we controlled for them. We counted all prior joint ventures and alliances a corporate investor had entered in the year prior to our observing the dependent variable, and all mergers and acquisitions the investor entered in that year. Data were obtained from the Securities Data Company (SDC) database.. We controlled for firm size using the natural logarithm of sales for firm i at time $t - 1$ because size can influence firm innovation both positively and negatively (Henderson & Cockburn, 1996; Katila, 2002). As R&D expenses influence a firm's propensity to innovate, studies using patents as a dependent variable (Ahuja & Lampert, 2001; Benner & Tushman, 2002) have controlled for these expenses. Since our R&D expenditure measure was highly correlated with firm size, we used R&D intensity, measured as the ratio of R&D expenditure to corporate investors' sales at time $t - 1$, as our control variable.

Since firm age exerts a systematic effect on the rate at which firms patent (Sorensen & Stuart, 2000), we controlled for the number of years from the founding of firm i to the year before the observation of the dependent variable. Further, we controlled for prior experience with CVC investments, which may also influence knowledge creation. The prior CVC experience of corporate investor i at time $t - 1$, measured with data from VentureXpert, was the number of years since a firm first began investing CVC funds.

We also controlled for knowledge relatedness between investor and portfolio firms since it can be correlated with innovation (Dushnitsky & Lenox, 2005). We were unable to use patent-based measures of relatedness because fewer than 50 percent of the portfolio firms in our sample had patents at the time of receiving investment. We chose to operationalize relatedness on the basis of industry and developed a concordance between the SIC codes assigned to the corporate investors and the VentureXpert Industry Classification Codes (VEIC) assigned to all portfolio companies. A portfolio firm was considered related to its corporate investor if any of the VEIC codes were found to match SIC codes at the three-digit (366) level. If a portfolio firm subsequently went public and was assigned an SIC code, we used this new code to determine relatedness. The measure was the average count of portfolio firms belonging to the same three-digit SIC code as a corporate investor i in year $t - 1$.

Since the quality of the portfolio firms' invested in could affect our dependent variable, we controlled for it by counting how many venture capitalists had invested in a portfolio firm by the time a focal corporate investor put money into it. This number was then computed for all the portfolio firms invested in by the corporate investor in any year of the sample. The number of investing VCs is often a good proxy for the quality of a start-up because VCs go through several stages of due diligence before making investments.

We measured our control and independent variables using a lag of one year from the year of observation of the dependent variable. Since we had no prior information about when a firm's CVC activities impact knowledge creation, we also experimented with a cumulative lag of two years. These results are discussed under robustness checks.

Model and Estimation

Since our dependent variable, rate of knowledge creation, was a count variable and took on nonnegative integer values, we used a nonlinear regression approach to avoid heteroskedastic, nonnormal residuals (Hausman, Hall, & Griliches, 1984). Specifically, we used the negative binomial regression model, a generalized form of Poisson regression, because the variance of our dependent variable exceeded its mean, indicating overdispersion in the data. This model took the form $\ln \lambda_i = \beta' x_i + \epsilon$, where λ_i equals the mean and variance of y_i, the observed frequencies for a random dependent variable Y ($i = 1, \ldots N$); x_i is the vector of regressors; and $\exp(\epsilon)$ has a gamma distribution with a mean of 1 and a variance of α^2 (Cameron & Trivedi, 1986).

Since the innovativeness of firms may also increase or decrease over time, we controlled for systematic period effects (factors not captured in the above control variables that might have a constant impact on all the firms in the sample but vary over time) by using dummy variables for $n - 1$ calendar years in the sample period up to year $t - 1$.

Observationally equivalent firms may differ on some unobservable or unmeasured characteristic. It is possible to correct for unobserved heterogeneity using random- and fixed-effects estimations. Since we had no prior information about the unobserved heterogeneity, we first conducted a Hausman (1978) test to check whether fixed- or random-effects models were more appropriate. The results were inconclusive, as the Hausman test did not converge for our data. Hence, we use both fixed- and random-effects estimators.

RESULTS

Descriptive Statistics

Table 1 reports descriptive statistics for all the variables of interest. The CVC investment and firm size variables have been log-transformed because they were highly skewed and kurtotic. Knowledge creation rate, measured as an annual patent count for each firm and varying between 0 and 2501, had a standard deviation greater than its mean, which indicates the overdispersion. Since the linear terms of variables are highly correlated with their higher-order terms (squared terms and the linear and quadratic interactions used to test our hypotheses), we followed Aiken and West (1991) and mean-centered all variables prior to creating the quadratic and interaction terms. This procedure reduces nonessential ill-conditioning between independent variables and their higher-order terms and facilitates better interpretation of coefficients (Cohen, Cohen, West, & Aiken, 2003). T1

We found the number of CVC investments and technological diversity to be positively and signif-

TABLE 1
Correlations and Descriptive Statistics[a]

Variable	Mean	s.d.	Minimum	Maximum	1	2	3	4	5	6	7	8	9	10	11
1. Patent count$_{it}$	352.32	497.40	0.00	2,501.00											
2. Number of CVC investments$_{it-1}$[b]	0.31	0.64	0.00	3.47	.12*										
3. Involvement$_{it-1}$	0.18	0.64	0.00	10.00	.01	.31***									
4. Technological knowledge diversity$_{i(t-1 \text{ to } t-4)}$	9.38	5.71	0.00	17.85	.64***	.11*	.03								
5. Patent stock$_{it-1}$	713.02	1,063.60	0.00	4,599.00	.75***	.04	−.05	.69***							
6. M&As, JVs, and alliances$_{it-1}$	17.06	20.33	0.00	118.00	.66***	.21***	.05	.57***	.62***						
7. Age$_{it-1}$	44.99	40.02	0.00	152.00	55***	.06	−.03	.66***	.63***	.54***					
8. Size$_{it-1}$[b]	8.17	2.50	0.64	11.49	.60***	.27***	.09†	.86***	.59***	.58***	.60***				
9. R&D intensity$_{it-1}$	0.10	0.13	0.01	1.78	−.12*	−.02	.02	−.35***	−.19***	−.13*	−.20***	−.47***			
10. CVC experience$_{it-1}$	11.91	5.10	1.00	28.00	.12*	−.15**	−.01	.14**	.11*	−.01	.08	.12*	−.09†		
11. Knowledge relatedness$_{it-1}$	1.38	2.69	0.00	13.00	.08	.71***	.33***	.09†	.02	.14**	.04	.15**	−.03	−.14**	
12. Quality of portfolio firms$_{it-1}$	0.09	0.26	0.00	2.00	.04	.40***	.33***	.04	−.07	.00	−.00	.06	.01	−.05	.49***

[a] $n = 383$.
[b] Log-transformed.
† $p < .10$
* $p < .05$
** $p < .01$
*** $p < .001$
Two-tailed *t*-tests.

icantly correlated with the rate of knowledge creation, but the correlation between involvement and knowledge creation was not significant. Technological diversity, in particular, was strongly correlated with the dependent variable ($r = .64$). Many of our control variables, such as prior patent stock, partnerships (M&A, JVs and alliances), age, and size, were significantly correlated with the dependent variable in expected directions.

Regression Models

We report the results of the fixed-effects and random-effects negative binomial regression analysis
T2 in Table 2. Model 1 is the unconstrained controls-only model. Model 2 introduces the number of CVC investments as linear and quadratic terms to test Hypothesis 1. Model 3 includes two additional independent variables: involvement with portfolio firms, and technological diversity. Model 4 incorporates the interaction effects to test Hypotheses 2 and 3: interactions of involvement and technological diversity with the linear term number of CVC investments, and interactions of involvement and technological diversity with the squared term, number of CVC investments squared. Thus, model 4 represents the fully specified fixed-effects model. Although not reported, all models include firm and time dummies to control for unobserved heterogeneity and time-varying factors. We also show the partial and fully specified random-effects models (Table 2, models 5–8).

Direct effects. Hypothesis 1 posits an inverted U-shaped relationship between the number of CVC investments and patent count, our proxy for knowledge creation. The results in model 2 and model 6 (Table 2) indicate that the linear term number of CVC investments is positive and significant ($p < .10$), and number of CVC investments squared is negative and significant ($p < .01$), thus supporting Hypothesis 1.

The insignificance of the linear term number of CVC investments in models 4 and 8 is perhaps the result of the collinearity introduced by the numerous interaction terms involving the linear term. Multicollinearity is common when interaction terms are entered together with their component terms in a regression equation (Jaccard & Turrisi, 2003). Although multicollinearity affects the standard errors and coefficients of simple component terms, it does not influence the efficiency of estimates of higher-order terms.

Moderator effects. To test for moderating effects on the curvilinear relationship, we created linear interaction terms composed of the number of CVC investments and each of the two moderating variables and quadratic interaction terms. We entered the moderators together as a block to account for their simultaneous effect on the dependent variables (Golden & Viega, 2005). Evidence of moderation is found when the quadratic interactions are significant in the hypothesized direction and the model fit improves (Golden & Viega, 2005).

Hypothesis 2 posits that corporate investor involvement positively moderates the relationship between number of CVC investments and knowledge creation. In model 4 (Table 2), our fully specified fixed-effects model, the interaction term is positive and statistically significant ($\beta = .71$, $p < .001$), and a log-likelihood test shows that inclusion of the quadratic interaction further improves model fit. The results are similar in model 8 (Table 2, $\beta = .67$, $p < .001$), our random-effects regression model. Hence, we claim support for Hypothesis 2.

To better interpret the interaction terms, we graphed the quadratic-by-linear effect using the procedure outlined in Cohen et al. (2003) and
Aiken and West (1991). Figure 2 shows that for F2
corporate investors with low involvement (one standard deviation below the mean), the rate of knowledge creation is lower than it is for investor firms with moderate involvement (at the mean value of involvement) and with high involvement (one standard deviation above the mean). In fact, the figure shows that greater involvement with portfolio firms has such a strong moderating effect that, at high levels of involvement and CVC investment, the relationship between number of CVC investments and rate of knowledge creation turns positive. The inflexion point of the inverted U occurs at lower levels of CVC investments, an expected finding, because the corporate investors in our sample invested in one start-up annually, on average.

Hypothesis 3 argues that technological diversity moderates the relationship between the number of CVC investments and the dependent variable. The quadratic interaction term, technological diversity by number of CVC investments squared, is statistically insignificant (Table 2, model 4). Thus, Hypothesis 3 is not supported.

Among the control variables, M&As, JVs, and alliances; investor size; and relatedness between an investor and its portfolio firms were consistently significant.

Robustness checks. To check for robustness, we ran additional regressions. First, we used alternative measurements of involvement, one of our independent variables. We separated the involvement variable into two variables—one capturing involvement through the formation of alliances between a corporate investor and portfolio firms, and

TABLE 2
Negative Binomial Models with Fixed and Random Effects for Knowledge Creation Rate[a]

Variables	Fixed Effects Model 1	Fixed Effects Model 2	Fixed Effects Model 3	Fixed Effects Model 4	Random Effects Model 5	Random Effects Model 6	Random Effects Model 7	Random Effects Model 8
Constant	−2.29*** (0.39)	−2.19*** (0.39)	−0.51 (0.44)	−0.36 (0.46)	−2.67*** (0.43)	−2.52*** (0.43)	−0.84* (0.43)	$-0.80^{\dagger}$ (0.45)
Independent								
Number of CVC investments$_{it-1}$		$0.19^{\dagger}$ (0.11)	0.24* (0.11)	0.10 (0.13)		0.25* (0.11)	0.28** (0.10)	0.11 (0.14)
Number of CVC investments$_{it-1}$ squared	−0.16** (0.05)	−0.18*** (0.05)	−0.15* (0.06)		−0.18*** (0.05)	−0.19*** (0.05)	−0.17* (0.07)	
Involvement$_{it-1}$			0.01 (0.03)	0.25* (0.12)			0.01 (0.03)	0.23* (0.12)
Technological knowledge diversity$_{i(t-1 \text{ to } t-4)}$		0.14*** (0.02)	0.14*** (0.02)			0.17*** (0.02)	0.17*** (0.02)	
Moderating								
Involvement$_{it-1}$ × number of CVC investments$_{it-1}$			−0.91* (0.37)				−0.85* (0.36)	
Technological knowledge diversity$_{t(t-1 \text{ tot } -4)}$ × number of CVC investments$_{it-1}$				0.01 (0.02)			0.01 (0.02)	
Involvement$_{it-1}$ × number of CVC investments$_{it-1}$ squared				0.71*** (0.20)				0.67*** (0.19)
Technological knowledge diversity$_{i(it-1 \text{ to } t-4)}$ × number of CVC investments$_{it-1}$ squared				−0.02 (0.01)				−0.02 (0.01)
Control								
Patent stock$_{it-1}$					0.00 (0.00)	$0.00^{\dagger}$ (0.00)	0.00 (0.00)	0.00 (0.00)
M&As, JVs, and alliances$_{it-1}$	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)	0.01*** (0.00)
Age$_{it-1}$	−0.01* (0.00)	−0.00 (0.00)	−0.01* (0.00)	−0.00 (0.00)	−0.01* (0.00)	−0.00 (0.00)	−0.01* (0.00)	−0.00 (0.00)
Size$_{it-1}$	0.37*** (0.04)	0.39*** (0.05)	0.19*** (0.05)	0.18*** (0.05)	0.40*** (0.05)	0.42*** (0.05)	0.21*** (0.05)	0.21*** (0.05)
R&D intensity$_{it-1}$	1.19** (0.38)	1.22** (0.39)	0.91* (0.37)	0.84* (0.38)	1.31** (0.40)	1.32*** (0.41)	1.09** (0.38)	1.05** (0.38)
CVC experience$_{it-1}$	0.02** (0.38)	1.22** (0.39)	0.91* (0.37)	0.84* (0.38)	1.31* (0.40)	1.32*** (0.41)	1.09** (0.38)	1.05*** (0.38)
Quality of portfolio firms$_{it-1}$	−0.01 (0.01)	−0.02 (0.01)	−0.03* (0.01)	−0.03* (0.02)	−0.01 (0.01)	$-0.02^{\dagger}$ (0.01)	−0.03* (0.01)	−0.03* (0.01)
Knowledge relatedness$_{it-1}$	0.42*** (0.10)	0.37*** (0.10)	0.30*** (0.09)	0.33*** (0.09)	0.40*** (0.10)	0.33*** (0.09)	0.26*** (0.09)	0.30*** (0.09)
df	17	19	21	25	18.00	20.00	22.00	26.00
Log-likelihood	−1,712.24	−1,704.14	−1,681.07	−1,672.14	−2,028.01	−2,017.47	−1,984.90	−1,974.55
Log-likelihood ratio		16.18	62.32	80.19		21.07	86.22	106.92
Wald χ^2	323.18***	347.35***	408.36***	422.59***	362.16***	401.43***	543.43***	578.05***

[a] $n = 383$.

$^{\dagger}p < .10$

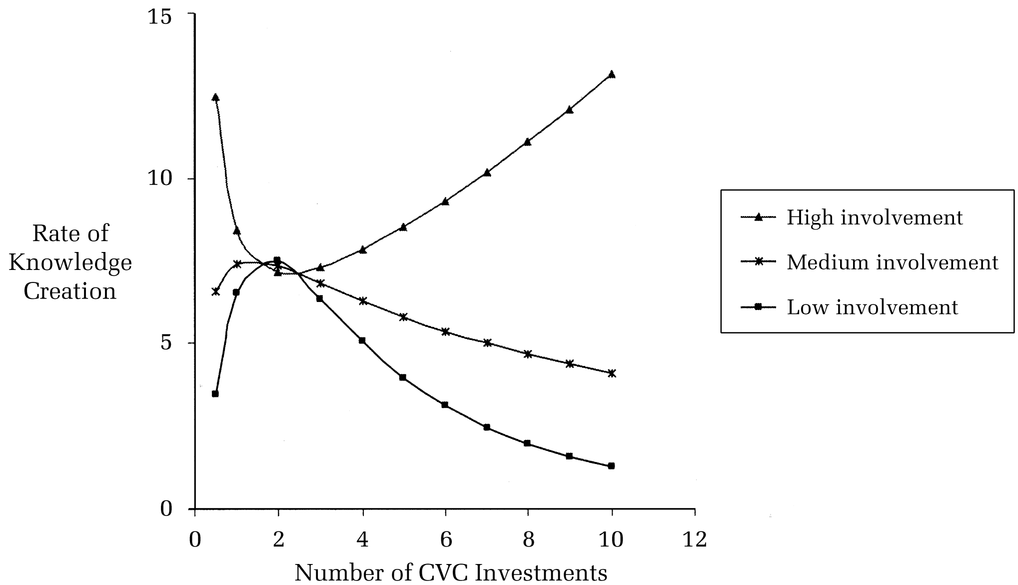
* $p < .05$

** $p < .01$

*** $p < .001$

Two-tailed tests.

FIGURE 2
Interaction Effect of Involvement[a]



[a]Lagged one year.

the other capturing involvement through board seats taken by the corporate investor in its portfolio firms. We ran two distinct fixed-effects regression
T3 models, which are reported in Table 3. Models A and B use alliances-only and board-seats-only, respectively, to operationalize involvement. Results indicate that although all models of involvement are significant, the coefficient of involvement measured as alliances-only (model A) is statistically stronger. We address these results in the discussion section.

Second, since we had no precedents for our use of a one-year lag in Table 2, we ran models using a "cumulative" lag of two years as an additional check for robustness.[5] Our results indicate that the main effect of number of CVC investments on knowledge creation is significant and has an inverted U-shape, but the moderating effect of involvement is statistically insignificant. The quadratic interaction of the number of CVC investments with the technological diversity is also insignificant in models with a cumulative two-year lag. The results from models with a two-year cumulative lag do not provide strong evidence for our moderating hypotheses. We address this lack of support in the discussion section.

[5] These tables are available from the authors upon request.

DISCUSSION

We conceptualized CVC investment activity as an exploratory process whereby firms employ these investments to search for new opportunities in their external environments. Subsequently, corporate investors, relying on involvement with portfolio firms and their technological knowledge diversity, can *use* their access to start-ups to accumulate knowledge from the investments and enhance their own potential to innovate. Our findings shed new light on the role played by contextual factors in overcoming the limitations inherent in exploratory activities (Levinthal & March, 1993).

The inverted U-shaped relationship between CVC investment and innovation found in this study suggests that this relationship may be more complex than previously thought. For example, our finding differs from the positive relationship found by Dushnitsky and Lenox (2005). Explanations for this difference may pertain to the differing approaches used. Dushnitsky and Lenox (2005) did not test for a nonlinear relationship between innovation and CVC investments, and their sample was drawn from a cross-section of industries, whereas our study focused on a single industry. Also, they measured the magnitude of CVC investment as the dollar amount invested by corporations. This measure captures a firm's overall involvement in external venturing activities such as CVC investment, but it provides limited information regarding the

TABLE 3
Comparison of Alternate Specifications of Involvement for Knowledge Creation Rate[a]

Variables	Alliances Only: Model A	Board Only: Model B
Constant	−0.32 (0.46)	−0.55 (0.46)
Independent		
Number of CVC investments$_{it-1}$	0.12 (0.13)	0.05 (0.16)
Number of CVC investments$_{it-1}$ squared	−0.20*** (0.06)	−0.08 (0.09)
Involvement—Alliance only$_{it-1}$	0.38* (0.18)	
Involvement (Board only)$_{it-1}$		0.83† (0.44)
Technological knowledge diversity$_{i(t-1 \text{ to } t-4)}$	0.14*** (0.02)	0.14*** (0.02)
Moderators		
Involvement—Alliance only$_{it-1}$ × number of CVC investments$_{it-1}$	−1.10* (0.47)	
Involvement—Board only$_{it-1}$ × number of CVC investments$_{it-1}$		−2.85* (1.40)
Technological knowledge diversity$_{i(it-1 \text{ to } t-4)}$ × number of CVC investments$_{it-1}$	0.00 (0.02)	0.01 (0.02)
Involvement—Alliance only$_{it-1}$ × number of CVC investments$_{it-1}$ squared	0.90*** (0.26)	
Involvement—Board only$_{it-1}$ × number of CVC investments$_{it-1}$ squared		1.81* (0.71)
Technological knowledge diversity$_{i(t-1 \text{ to } t-4)}$ × number of CVC investments$_{it-1}$ squared	−0.01 (0.01)	−0.01 (0.01)
Controls		
M&As, JVs, and alliances$_{it-1}$	0.01*** (0.00)	0.01*** (0.00)
Age$_{it-1}$	−0.00† (0.00)	−0.00 (0.00)
Size$_{it-1}$	0.18*** (0.05)	0.19*** (0.06)
R&D intensity$_{it-1}$	0.82* (0.38)	0.95* (0.37)
CVC experience$_{it-1}$	0.02** (0.01)	0.03*** (0.01)
Quality of portfolio firms$_{it-1}$	−0.03 (0.02)	−0.03* (0.01)
Knowledge relatedness$_{it-1}$	0.29*** (0.09)	0.35*** (0.09)
Observations/*df*	383/25	383/25
Log-likelihood	−1,671.37	−1,676.58
Wald χ^2	421.76***	423.68***

[a] Fixed-effects models.
† $p < .10$
* $p < .05$
** $p < .01$
*** $p < .001$
Two-tailed tests.

dispersion of portfolio firms—that is, about how many *different* firms the corporate investor invested in annually. Despite these differences, both findings highlight and empirically support the important link between CVC investments and innovation. When viewed together, the findings suggest that when a corporate investor's involvement capability is limited, it may be better for it to invest larger sums of money into fewer CVC investments. However, when the investor's involvement capability is high, it may be better for it to spread the larger sum over a larger number of CVC investments.

We argued that two important factors—corporate investor involvement and technological diversity—moderate the direct relationship between the number of CVC investments and knowledge creation. We viewed these factors as necessary for generating valuable knowledge resources from investors' access to portfolio firms. We posited that the first moderator, corporate investor involvement, would strengthen the relationship between the number of CVC investments and rate of knowledge creation. We found the effect to be strong enough to change the *directionality* of the main relationship. As seen in Figure 2, when involvement is high, its moderation effect is strong in that it *reverses* the inverted

U-shaped relationship between number of CVC investments and knowledge creation, which becomes a J-shaped relationship. Broadly, this finding underscores the importance of involvement as a mechanism whereby corporate investors can capitalize further on available opportunities and suggests that, although CVC equity investments may provide governance advantages through ownership rights, it is involvement with portfolio firms that helps investors gain knowledge benefits. An explanation for this effect may be that after a corporate investor has experimented with involvement in its first portfolio firm, it may attempt to generalize the process and type of involvement to subsequent portfolio firms. However, if subsequent portfolio firms are different from the first one, or if they possess unique types of knowledge, then a single strategy of involvement with portfolio firms may be less useful. As firms gain experience with involvement, they may be able to improve the knowledge creation rate significantly by applying appropriate involvement strategies to their portfolio firms.

This study measured two different types of involvement, alliances and board seats. We found that alliance relationships had a stronger moderating effect than board seats. Perhaps alliances engage partners at an operational level and thereby enable the formation of links between portfolio firms and business units of a corporate investor. Board seats, in contrast, are less action-oriented and provide corporate investors with a bird's-eye view of the new technologies being developed by portfolio firms. This finding highlights the role played by relationships in investors' gaining an understanding of the tacit and complex components of knowledge that may be deeply embedded in start-ups and may take longer to uncover without some relational elements in place.

Technological diversity, our second potential moderator, did not moderate the main relationship. In our arguments for moderation, we assumed that the number of CVC investments made by a corporation was directly proportional to the probability that this investor was exposed to different knowledge streams emanating from its portfolio firms. A possible explanation for the lack of moderation is that start-ups in investor portfolios may lack the assumed diversity. In other words, the investor firms in our sample may have been overly focused on certain types of target firms and, by overspecializing (building portfolios of start-ups belonging to the same industry segment as themselves, or focusing on the same technology as each other), they may have exhausted the recombinatory pool from new knowledge acquisition.

We also found that the direct effect of CVC investments on knowledge creation and the moderation effect of involvement on this relationship were strongest in one-year lagged models. Given the extremely rapid rate of change and technological obsolescence in the telecommunications equipment industry, this result was not surprising; perhaps one year is sufficient for most forms of technological knowledge creation in this industry, or perhaps knowledge older than a year is no longer of competitive value to a corporate investor. Another explanation for the lag structure lies in the myriad technologies required for a complete solution in this industry. Alternatively, the portfolio firms are able to supply a piece of technology, which can help renew or complete a set of technologies already possessed by the corporate investor.

Contribution, Limitations, and Future Research

Given the nascent nature of research on corporate venture capital investments, and their purported salience in enabling large companies to generate knowledge and innovations, this study attempts to examine systematically some fundamental questions key to developing a theory-based understanding of this phenomenon. We contribute to the literature on corporate entrepreneurship by highlighting the limits of CVC investments. This is one of the few studies that focuses on organizational learning and knowledge creation via exploration to extend and enrich the corporate entrepreneurship and the broader organization literature on knowledge sourcing and innovation.

We also contribute to the search literature by framing CVC investments as a search mechanism for external knowledge sourcing and by testing empirically for firm-level factors (e.g., involvement and technological diversity) that make exploratory search via CVC investments more effective. We show that exploration activities are characterized by negative marginal returns beyond a given point, an important finding that highlights the dilemma organizations face as they try to balance the exploration and exploitation modes of learning (Levinthal & March, 1993). We also empirically demonstrate the potential of involvement to reverse negative marginal returns to exploration via CVC investment. This finding illustrates that learning occurs only between organizations that are linked via knowledge transfer relationships and not between organizations without those links (Ingram, 2002).

Finally, the findings provide practical insights for CVC program managers regarding knowledge creation outcomes. One of the critical findings in this study is that the number of CVC investments likely to deliver learning-related benefits is extremely low, and increasing the number of investments has its downsides—too many CVC investments may not be costless. However, if managers actively manage and augment their CVC investments with other interorganizational relationships, they may be able to unlock the learning potential inherent in their affiliations and generate greater value from multiple CVC investments.

This study is not without limitations. Our use of archival data may been limiting. For example, we could not directly test knowledge flows between corporate investors and their portfolio firms. Given that only about 50 percent of the start-up firms in our sample had patents at the time they received corporate investments, it was impossible to determine, through archival data, whether corporate investors in our sample cited the patents of start-ups they invested in. Further, we assumed, on the basis of anecdotal data and academic surveys, that the primary motives for corporate investors are strategic. We were unable to get finer-grained data on corporate investors' objectives when making CVC investments, but it is possible that some investors may have exploratory versus exploitative motives. Future studies should attempt to capture these goals and their effects on corporate investors. Another possible limitation resulting from the use of archival data pertains to possible unobserved heterogeneity owing to the absence of variables capturing characteristics of the start-up firms studied. Although we controlled for relatedness and start-up quality, information on other characteristics that could affect investor innovation rate, such as geographical or knowledge distance, was unavailable. We are confident that using fixed-effects models mitigated this concern. Nevertheless, it is important that researchers incorporate investee characteristics as part of their analyses.

Using patent data as a proxy for knowledge creation is perhaps another limitation. Because patents may not capture all types of knowledge created within an organization, our findings do not account for noncodified knowledge resulting from CVC investment activity. Thus, we might be underestimating the benefits of CVC investments. However, our findings are still robust and in the expected direction. Another, related limitation of our patents count proxy is the possiblility that firms may file large numbers of patents or file more novel patents for reasons we did not observe. Our use of control variables and a fixed-effects specification should have helped overcome this limitation, however. It also presents opportunities for employing other dependent variables (e.g., new product development) in future research as proxies for knowledge creation.

Finally, we limited our investigation to a single industry. A few scholars have observed that in high-technology industries, where rapid technological change is the norm, few organizations are able to build capabilities without access to external knowledge (e.g., Leonard-Barton, 1995). Although this view suggests that our findings may be applicable beyond the telecommunications equipment manufacturing industry, it is important that researchers test the generalizability of our findings in other industries.

Another avenue for future research is to examine why technological diversity did not moderate the relationship between CVC investments and innovation. Researchers could explore the association between relatedness, diversity, and innovation and examine whether corporate investor firms that search broadly, but within areas related to their existing knowledge domains, exhibit greater levels of innovation than firms that do not.

In conclusion, we note that scholars have emphasized exploration as an imperative for organizations seeking to create new knowledge and new possibilities (March, 1991), and at the same time have pointed out the detrimental effects of too much exploration. Our study integrates insights from the exploratory search and organizational learning literatures to empirically confirm the negative effects of too much exploration via CVC investments in new ventures. We also show that corporate investors can overcome these negative effects and achieve superior outcomes by adding a relational dimension to their equity links with entrepreneurial firms. We hope that our findings catalyze further work in corporate entrepreneurship.

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