CROSSING THE ORGANIZATIONAL SPECIES BARRIER: HOW VENTURE CAPITAL PRACTICES INFILTRATED THE INFORMATION TECHNOLOGY SECTOR

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We examine the contagion processes whereby practices originating in one organizational population spread into and diffuse within a second. We theorize that "endemic" innovations native to one population spread to other populations through two distinct forms of contagion. We test this argument by observing information technology firms' adoption of corporate venture capital programs. Results suggest that geographic proximity triggers cross-population contagion, that within-population contagion arises from different causal mechanisms, and that firms maintaining close cross-population ties pay less attention to the actions taken and outcomes experienced by other firms within their own industry.

Fueled by emerging technology and a robust economy, corporate equity investing in start-up ventures exploded in the 1990s. The decade's last five years alone saw a 3,800 percent increase, as corporate venture capital investments grew from $172 million to $6.8 billion (Venture Economics, 2006). Corporations scrambled to establish venture capital programs, identify best practices, and take equity in young entrepreneurial ventures. Rene Savelsberg, head of Philips's corporate venture capital arm, described his program's genesis as follows:

We first got interested in corporate venture capital through our marketing relationship with WebTV back in 1997. At that time, this start-up company, literally working out of a garage, approached me about signing a marketing relationship with them. What we found was that they were much further advanced than our own internal development group. As a result, we decided to go ahead. The next week, they announced to the world that we had signed a marketing agreement with them. Four months later, they were sold out to Microsoft for $400 million. Our board saw this deal and said, "Wait a minute, it was the Philips name and back-

ing that created that $400 million. Otherwise, they would have had no credibility. We have to do more . . . to capture some of that value that has been created. (Henderson & Leleux, 2002: 432)

The prospect of capturing financial value may have galvanized the Philips board into establishing a venturing arm, but many corporate programs cite strategic returns as their primary objective (Dushnitsky & Lenox, 2006). Proponents hail corporate venture capital programs as vehicles for strategic renewal that can import "disruptive technologies" and new business models into established corporations. Recent research offers support for such claims by linking corporate venture capital (CVC) programs with increased knowledge creation (Wadhwa & Kotha, 2006) and higher rates of technological innovation (Dushnitsky & Lenox, 2005). Some scholars have characterized corporate venture capital programs as complements to orthodox R&D (Dushnitsky & Lenox, 2005); others have gone further, suggesting that CVC can even replace in-house R&D—in effect, outsourcing it to start-ups (Rausch, 2004).

The venture capital model is widely acknowledged as a powerful, disciplined tool for making investment decisions in the face of risk and uncertainty. However, transplantation of the private VC model into the public corporation is difficult and fraught with risks (Gompers & Lerner, 2001a). The venture capital model was originally formulated within a cottage industry where a small set of close-knit partnerships invented practices for vetting and syndicating deals, mentoring and monitoring the

companies they funded, and spurring them on either to fail early or to grow exponentially into businesses that could be sold to stock market investors. Some of the knowledge that venture capitalists (VCs) possess is tacit, and certain VC practices clash with the compensation systems and organizational cultures of the corporations seeking to adopt CVC programs. So corporate venture capital investing programs are hard to design and operate (Gaba & Meyer, 2006). Aggregate levels of equity investing fluctuate with economic cycles. Many firms that set up CVC units during the 1990s closed them after 2000 in the face of mounting financial losses. One critic went so far as to characterize the contagious spread of CVC programs in the 1990s as "the lemmings' march toward financial immolation" (Edelson, 2001: 41).

When we set out to model the diffusion of corporate venturing programs in the information technology (IT) sector, our exploratory analyses showed that "CVC diffusion could not be understood without broadening the scope of observation to encompass the larger set of organizational forms and populations that make up the VC community" (Meyer, Gaba, & Colwell, 2005: 465). Accordingly, our focus here extends beyond the population of firms comprising the IT industry to include the private partnerships that pioneered venture capital practices in the first place. In doing this, we follow the counsel of Davis and Marquis (2005: 341) to pursue mechanism-based theorizing, taking the organizational field (rather than the organizational population) as the unit of analysis. These authors urged researchers to focus explicitly on organizational fields and social mechanisms: "*fields* because substantial economic change does not stay contained within organizational or industry boundaries, and *mechanisms* because the quality of explanation is enhanced by an explicit focus on the cogs and wheels behind the regression coefficients" (Davis & Marquis, 2005: 341; emphasis added).

The diffusion mechanisms we propose for CVC programs are analogous to the transmission of an organism native to one specific organizational population (private venture capital partnerships) across the species barrier, into another organizational population (publicly held information technology corporations). The spatial or geographic diffusion of venture capital between regions and nations has been investigated extensively in prior work (Bruton, Fried, & Manigart, 2005; Guler & Guillén, 2005; Sapienza, Manigart, & Vermier, 1996). However, the spread of venture capital and other innovative practices among organizational forms or populations has received scant attention. We focus upon innovations endemic to an originating population

that mutate and jump to an adjacent organizational population. We develop theory specifying the social mechanisms involved, and hypothesize their direct and interactive effects upon innovation adoption. Conceiving of diffusion as a social process directs one's attention to the role that propinquity plays in facilitating the transfer of knowledge. Accordingly, in spelling out the cogs and wheels involved in CVC diffusion, we draw upon the literature on knowledge spillover within geographically proximate regional clusters (Jaffe, Trajtenberg, & Henderson, 1993; Saxenian, 1994).

We test our predictions by studying the bundle of innovative practices developed within clustered enclaves of private VC partnerships that penetrated and spread within the population of publicly traded IT corporations. First, we explicate and model the mechanisms through which VC practices come to be modified for and adopted by IT corporations. This argument focuses upon *cross-population contagion* arising from IT firms' social ties and proximity to the VC population clusters, coupled with evidence documenting the efficacy of VC practices. We proceed to examine a second set of contagion processes, *within-population contagion,* that transmitted the modified VC model from early IT adopters to later IT adopters. Here, we focus on CVC programs' popularity within the IT industry, the prominence of prior IT adopters, evidence bearing on benefits accruing to IT adopters, and geographic proximity to prior IT adopters. Finally, we consider how these cross-population and within-population contagion processes interact.

Our article makes three contributions. First, by investigating the spread of corporate venture capital, we shed light on the swift but erratic diffusion of this novel form of strategic investing. Second, our analyses illustrate how innovations penetrate the boundaries separating organizational populations—a relatively unexplored issue in the innovation diffusion literature. By disentangling cross- and within-population contagion mechanisms, we offer a more nuanced understanding of the dynamics of innovation diffusion. Third, we focus attention on the spread of "endemic" innovations, showing that geographic proximity to the originating population may be especially crucial in accelerating the diffusion of such innovations.

INNOVATION, CONTAGION, AND POPULATION

Endemic Innovations

In biology and ecology, "endemic" means *exclusively* native to a place or biota, in contrast to var-

ious terms signifying "not native," such as "exotic," "alien," "introduced," or "naturalized." A species that is endemic is unique to that place or region, found naturally nowhere else. In this article, we apply the term "endemic innovation" to an innovation that, when first introduced, is exclusively native to a specific organizational population.

Many innovations, of course, spread readily among populations. The boundaries separating organizational populations have done little to slow the contagious spread of equipment-embodied innovations like personal computers, or innovative financial arrangements like golden parachutes and poison pills (Davis & Greve, 1997). Other innovations, however, are turned back at the population border. Innovations can remain endemic to the organizational population constituted by an industry, geographic region, nation-state, or cultural system. Potential barriers to extra-population contagion of endemic innovations include institutional norms, industry standards, technology platforms, regulatory regimes, and cultural practices. However, some endemic innovations undergo changes that breach contagion barriers, allowing the innovations to take hold and diffuse within new organizational populations. One example is the computer software industry's "open-source" business model, whereby source code is shared freely and all programmers are invited to contribute to its further development (Wayner, 2000). After remaining endemic to software development for over a decade, the open-source model has "morphed" into variants that have been adopted by biotech research labs, industrial design firms, and NASA's mission to Mars (Goetz, 2003). Other examples are the "lean production" model that originally was endemic to Japanese manufacturing (Womack, Jones, & Roos, 1990), and the microfinancing model, endemic to nongovernmental organizations but currently diffusing rapidly in the commercial banking sector (Armendariz de Aghion & Morduch, 2005). All of these innovations were initially native to a defined organizational population but underwent modification, enabling their diffusion into other populations.

We turn now to the set of innovative practices developed by private venture capital firms, arguing that they constitute an endemic innovation that has undergone modification, enabling the innovation's adoption within information technology corporations.

Venture Capital: The Genesis of an Endemic Innovation

The venture capital model incorporates a novel set of practices for finding, financing, growing, and commercializing entrepreneurial start-ups (Gompers & Lerner, 2001b; Kenny & Florida, 2000). Venture capitalists are professional investors who raise funds from wealthy individuals, insurance companies, pension funds, and other institutions wishing to take equity positions in entrepreneurial ventures but lacking the ability to identify, manage, and harvest these investments themselves. VCs winnow, select, and take equity in young companies with the potential to grow exponentially and achieve a dominant market position. The VCs scrutinize an investment prospect's business plan, technology, intellectual property, and management team; invest their financial capital; and often become actively involved in advising, monitoring, and building the company. To mitigate the extreme risks attendant to investing in early-stage companies, venture capitalists deploy their funds across portfolios of young companies and often syndicate their deals by coinvesting alongside other VCs.

Since there is no market for unregistered securities, venture returns must be realized either through the acquisition of a VC-backed start-up by an established corporate buyer, or through the issuance of shares in an initial public (stock) offering (IPO). The IPO is the outcome preferred by all participants; it achieves the highest valuation for the young company, provides liquidity to the investors, and preserves the company's independence (Gompers & Lerner, 1999).

Established financial institutions did not conceive the VC model. Instead, it emerged organically within informal networks of geographically clustered private investors. The origins of venture capital can be traced to American Research and Development in 1946 (Gompers & Lerner, 1999). The first venture capital partnership was formed in 1958 by Draper, Gaither, & Anderson (DGA; Gompers & Lerner, 1999). DGA's enduring legacy was to establish the limited partnership as an organizational form (Kenney & Florida, 2000), incorporating a distinctive set of practices for finding, funding, and commercializing novel technologies (Gompers & Lerner, 2001b). The challenges faced in mobilizing capital and the need to share information and expertise led pioneering venture capitalists to join forces, evolving into an interactive community exchanging information, advice, gossip, and referrals of opportunities (Bruton, Fried, & Manigart, 2005; Kenney & Florida, 2000).

Forty years later, geographic clustering remains a distinctive feature of the venture capital population (Cook, 2001; Sorenson & Stuart, 2001). As suggested in Figure 1, almost two-thirds of all VC investments in the United States were concentrated near California's Silicon Valley, New York City,

FIGURE 1
Geographic Distribution of VC Investments in Millions of Dollars
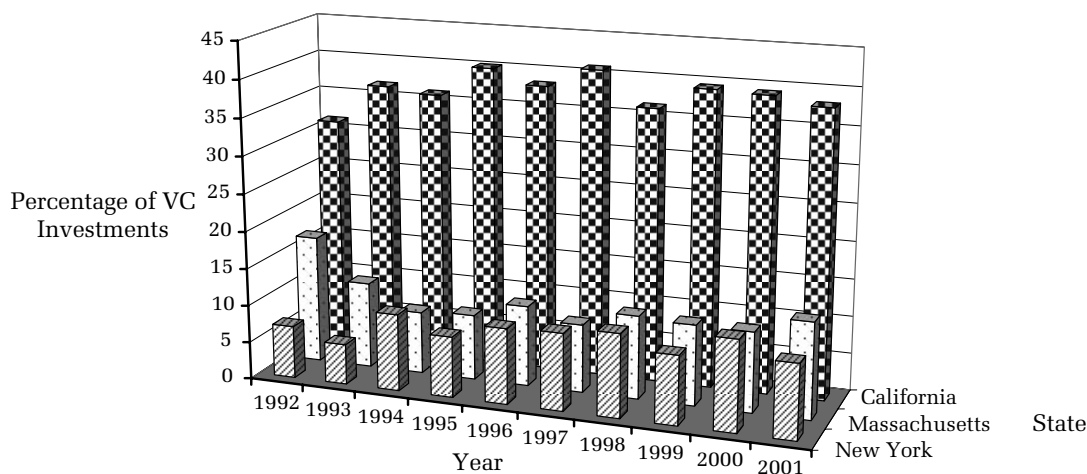
and New England's Route 128 during the time period of this study.

The Haphazard Diffusion of Venture Investing to Corporations

Over the years, corporations have tried repeatedly to stimulate innovation and growth by separating their new business endeavors from their current business structures. Often, the results have been disappointing (Chesbrough, 2000). Many of the best corporate ideas languished or were commercialized only when defecting employees founded new firms (Gompers & Lerner, 2001a). In the late 1960s, a number of forward-looking corporations sought to emulate the venture capital model by making equity investments in external start-ups. By the early 1970s, over 25 percent of the *Fortune* 500 had initiated venture capital programs (Rind, 1981). But in 1973, the market for public stock offerings declined abruptly, the pool of private venture capital dried up, and corporations began scaling back their own venture capital programs. Corporate venture capital efforts that began in the 1960s were typically shuttered after operating just four years (Gompers & Lerner, 2001a). Some private VCs labeled CVC programs "fair-weather investors"; others scorned them as "dumb money," because of their propensity to overpay for deals pursued for strategic rather than financial reasons (Alistair, 2000). Academic researchers highlighted a number of factors thought to have contributed to CVC program abandonment: poorly articulated venturing strategies (Seigel, Seigel, & MacMillan, 1988), insufficient top management commitment (Sykes, 1990), incompatible organizational cultures (Rind, 1981), and inadequate compensation schemes (Block & Ornait, 1987). Some observers concluded that the venture capital model was, in effect, intrinsically endemic to the private VC population (Edelson, 2001).

Corporate Venturing in the 1990s

In the mid 1980s, disappointing returns from internal R&D and shifts in federal antitrust policy led many firms to begin to externalize their R&D operations (Mowery, 1999). Meanwhile, Silicon Valley venture capitalists were gaining celebrity status by spotting promising business opportunities, accelerating the progress of new ventures through their early development, and helping these ventures achieve liquidity. By the late 1990s, the cachet of venture-backed firms like eBay and Yahoo! had reignited corporate interest in the VC model (Gompers & Lerner, 2001a).

This boom in venture capital was unprecedented (Gompers & Lerner, 2001b). Researchers calculated that a dollar invested in venture capital was, on average, three or four times as potent in stimulating innovation as a dollar invested in traditional R&D (Kortum & Lerner, 2000). Total VC investments surged from less than $4 billion in 1994 to $43 billion in 1999. The corporate share of venture capital investments increased even more dramatically, growing from 2 percent in 1994 to 17 percent in 2000. By mid 2000, some 350 corporate venture capital funds were reported to exist worldwide, up from less than a dozen in 1990 (Venture Economics, 2001).

During the 1990s, information technology corporations were in the vanguard of CVC program adoption. Figure 2 shows that the IT sector was the destination for over two-thirds of all venture capital investments. Digital Equipment Corporation,

FIGURE 2
Industry Distribution of VC Investments in Millions of Dollars
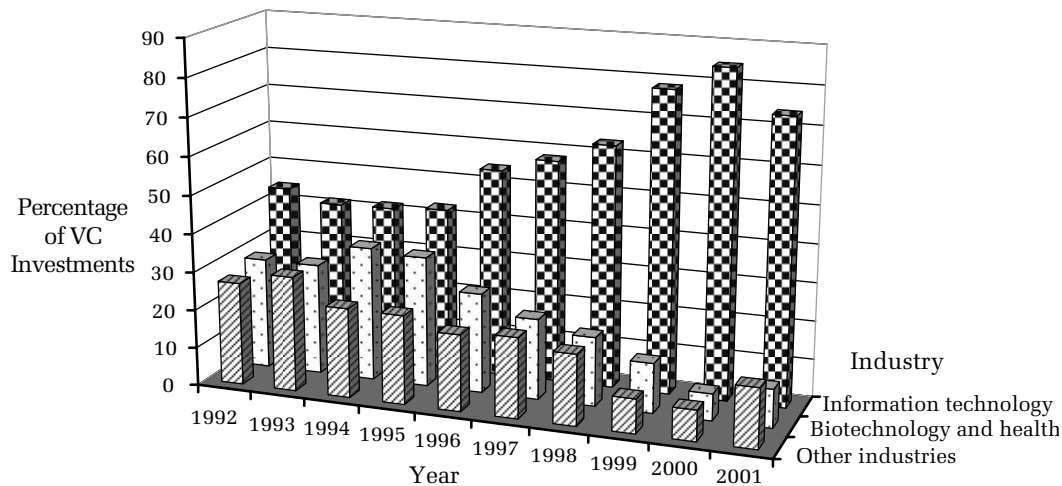
Apple, Intel, Compaq, and Sun Microsystems are prominent examples of firms that received venture capital early in their development. Given the central role of venture capital in funding IT, it was logical that these firms pioneered efforts to assimilate the VC model into their own operations.

Modifying the VC Model

We define the adoption of a corporate venture capital program as occurring when an established corporation creates a structurally distinct entity dedicated to making external equity investments in a portfolio of high-potential young enterprises. CVC units can assume a variety of structural forms (Gaba & Meyer, 2006; Gompers, 2002), which include autonomous subunits reporting to the corporation's top management team, limited partnerships whose sole limited investor is the parent corporation, and durable alliances between the corporation and a private VC firm intended to assemble a dedicated portfolio of investments tailored to fit corporate strategic objectives.

Many innovations must be modified to fit an adopting organization's idiosyncratic context (Abrahamson, 2006; Rogers, 1995), and innovations endemic to an alien organizational form call for even more extensive modification. Although they are modeled upon the practices of private VC firms, corporate programs have distinctive features. First, unlike private VCs, CVCs do not raise funds from institutional investors; in most cases they tap the corporate treasury to fund their CVC programs (Chesbrough, 2000). Second, unlike private VCs, whose central objective is to maximize financial returns, most corporations pursue strategic objec-

tives as well: early exposure to disruptive technologies, access to new markets and business models, and identification of prospective targets for acquisition (Chesbrough, 2000; Dushnitsky & Lennox, 2006). Third, unlike private VCs, CVC staff seldom become the lead investors in syndicated investments or take seats on boards of start-up ventures, preferring to coinvest alongside private VCs who lead deals and take board seats (De Clercq, Fried, Lehtonen, & Sapienza, 2006). Fourth, financial returns to private VC partners come primarily from cashing in equity stakes in portfolio companies, but corporations cannot devise compensation schemes offering equivalent payouts without creating intractable conflicts of interest and wreaking havoc on internal corporate incentive systems (Block & Ornait, 1987).

These differences notwithstanding, CVC programs retain key operational characteristics of the private VC model, such as due diligence, deal making, and syndication. Corporate venture investors can complement private investors, adding unique value to start-up companies by tapping their deep knowledge of the IT industry and its core technologies, serving as a "beta site," providing access to marketing and distribution channels, and conferring legitimacy and *gravitas* upon a new venture (Chesbrough, 2000; DeClercq et al., 2006).

In sum, innovative investing practices devised by private venture capital partnerships in the 1950s remained, by and large, endemic to the VC population until the 1990s, when these practices, repurposed to pursue strategic in addition to financial objectives and remodeled to fit corporate structures, began diffusing to public corporations, with IT firms in the vanguard. In the next section, we

propose theoretical mechanisms responsible for their cross-population diffusion and subsequent within-population diffusion.
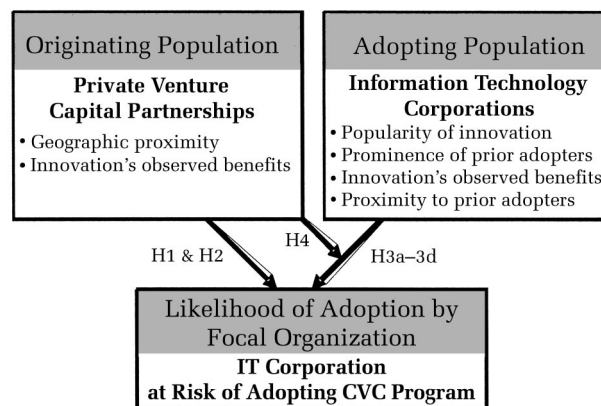
THEORY AND HYPOTHESES

How and why do novel practices spread among the actors who make up a social system? Reviews of the diffusion literature show that few research questions have spanned so many social science disciplines, inspired such an outpouring of research, or aroused such enduring interest (Rogers, 1995; Strang & Soule, 1998). Most of this work "treats diffusion as a primarily, or even exclusively, relational phenomenon" (Strang & Meyer, 1993: 487) whose fundamental rate varies with the level of connectedness and interaction between prior and potential adopters of an innovation. Yet empirical findings are equivocal, and scholars' cumulative knowledge of why and how innovations come to be adopted "is considerably less than the sum of its parts" (Meyer & Goes, 1988: 897).

Because purely relational models have yielded unsatisfactory explanations, a number of scholars have incorporated contextual factors thought to affect diffusion. For instance, the rate and form of diffusion have been said to be shaped by institutional and cultural conditions (Strang & Meyer, 1993), network structures of regional geographic clusters (Saxenian, 1994), fieldwide macrocultures (Abrahamson & Fombrun, 1994), and the influence of mass media (Strang & Macy, 2001).

A number of prior studies have addressed the spread of organizational innovations across geographic space (e.g., Greve, 2005). In the case of venture capital, after originating in the United States, the model spread first to England and Western Europe in the late 1970s, and then to Asia in the mid 1980s (Bruton et al., 2005; Sapienza et al., 1996). Researchers have reported that the geographic dispersion of VC seems to be linked to differences in national innovation systems, financial markets, political institutions, and social proximity (Guler & Guillén, 2005). Venture capitalists' depth of involvement in portfolio companies and beliefs about how much value they add have been found to vary across countries (Sapienza et al., 1996).

Saxenian (1994) argued that differences in regional network structure explain why Silicon Valley adapted more effectively to technological change than Boston's Route 128. Suchman and Cahill (1996) described how law firms boosted Silicon Valley's entrepreneurial vitality by helping forge these network relationships in the first place and institutionalizing "term sheets"—the contractual covenants that codify and accelerate new firm formation.

FIGURE 3
Cross-Population Diffusion of Endemic Innovations

Although social scientists have studied the diffusion of innovation among geographic populations, they have not considered how the characteristics of *organizational* populations influence the contagious spread of innovations. No studies have scrutinized innovations that emerge as endemic to a specific organizational population of adopters, examined how such innovations breach population boundaries to spread into adjacent organizational populations, or specified the different contagion mechanisms underlying within- and between-population diffusion.[1]

In this section we develop such a model. Our objective is to understand the transfer of innovative practices originating elsewhere into the organizations that comprise a separate and distinct organizational population. Our model distinguishes between two forms of contagious diffusion: One form operates *across* the boundary separating two organizational populations, and the other operates *within* a single population. *Cross-population contagion* transports an endemic innovation from an originating population, where it was originally conceived, into an adopting population, where it is subsequently adapted and implemented. *Within-population contagion* spreads a formerly endemic innovation from prior adopter to prospective adopter within a new organizational population. Figure 3 illustrates our model, showing the prin-

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[1] Community ecologists and institutional theorists have long been concerned with how two or more organizational populations interact in organizational fields, but neither group has focused upon innovation diffusion as a core mechanism linking two populations.

cipal mechanisms we consider, and indicating how these map onto the empirical setting we studied.

Cross-Population Diffusion of Innovations

How do innovative practices endemic to one organizational population spread into another population? We focus on two mechanisms: direct exposure to the innovation afforded by geographic proximity to the originating population, and evidence of beneficial consequences flowing from the innovation.

Geographic proximity to the originating population. The role of geography in structuring interactions and shaping strategic decisions has long interested sociologists and economists. Geographic clustering creates external economies arising from information spillovers and access to specialized services and skilled labor (Audretsch & Feldman, 1996; Krugman, 1991). Researchers have argued that geographic clusters facilitate the transfer of knowledge between firms operating within a region (Jaffe et al., 1993; Saxenian, 1994; Sorenson & Audia, 2000). These knowledge spillovers occur as firms collaborate, as their members interact at social and professional gatherings, and as workers leave one firm to work for another. Saxenian (1994) reported that in Silicon Valley, geographic proximity has promoted repeated interactions that build trust, foster collaboration, and fuel a continual recombination of technologies and skills.

Geographic proximity to a VC population cluster affords a prospective IT adopter direct exposure to the innovation itself, in situ. It allows members to obtain first-hand knowledge about the VC model—the requisite skills, values, procedures, behaviors, and know-how involved (Audretsch & Feldman, 1996). Proximity helps foster social relationships that boost the prospective adopter's confidence in the accuracy and quality of innovation-related information (Owen-Smith & Powell, 2004; Sorenson & Audia, 2000). We expect that IT firms headquartered near a venture capital cluster will find it easier to acquire both tacit and codified knowledge about VC practices. Such firms are likely to be more cognizant of the "agency risks" implicit in funding start-ups, and better equipped to monitor their portfolio companies to mitigate such risks. In addition, executives of proximate firms are likely to be embedded in social networks that include private venture capitalists who can feed them an ongoing flow of deals.

Accordingly, we hypothesize that variation in IT firms' proximity to a VC population cluster creates differentials in the amount and quality of information they acquire, leading to variation in the likelihood of adoption of CVC programs.

> *Hypothesis 1. Geographic proximity to a VC population cluster increases the probability of CVC program adoption by an IT firm.*

Observing success in the originating population. So far, our argument has emphasized direct exposure to innovative practices and their pioneering practitioners as the mechanism enabling an endemic innovation to penetrate and spread within a new organizational population. However, most firms presumably adopt innovations with the expectation of achieving substantive benefits. If so, vivid and reliable evidence that an endemic innovation is paying off for firms in another population should persuade performance-oriented decision makers to consider adopting it themselves. Surprisingly, mainstream diffusion theories have largely ignored how prospective adopters are influenced by the results achieved by prior adopters in other populations. However, it was the discovery of new drugs by small biotech start-ups that led large pharmaceutical firms to adopt recombinant DNA technology (Barley, Freeman, & Hybels, 1992). Similarly, the microcredit investing model spread from nongovernmental organizations (NGOs) into the financial services sector in the wake of a 1997 United Nations study reporting that default rates of impoverished borrowers in developing countries were comparable to or lower than the rates for traditional banks (United Nations, 1997).

The impacts of VC investment on new venture formation, value creation, and regional economic development received widespread publicity in the 1990s. Although venture capital firms invest in only a few hundred of the nearly one million new U.S. businesses established each year, roughly one-third of those that went public in the past two decades were backed by venture capitalists (Gompers & Lerner, 1999). Despite their small numbers, VC-backed companies often prove to be wellsprings of technological innovation and continue to outperform non-venture-backed companies long after they go public (Brav & Gompers, 1997). Kortum and Lerner (2000) found that although VC investment in biotechnology has averaged less than 3 percent of R&D investment, firms with VC backing produced nearly 15 percent of biotech innovations.

The initial public offering, as noted earlier, provides the most desired and closely monitored signal of the success of a venture capital investment. The number of IPOs varies from year to year, driven by movement through aggregate venture capital cycles and rates of innovation in technology and busi-

ness models. Thus, the incidence of recent VC-backed IPOs provides a salient indicator of the overall success of the private venture capital model, attracts the attention of potential corporate adopters, and increases their receptivity to establishing a CVC program.

Hypothesis 2. The likelihood of CVC program adoption by an IT firm is positively related to the efficacy of the investments made by the VC population.

Within-Population Diffusion of Innovations

Once an endemic innovation has been revamped and implemented in a nonnative population, new contagion mechanisms come into play. This need not terminate the initial cross-population contagion processes, but it supplements them by introducing new channels for the contagious spread of the modified innovation. As shown on the right side of Figure 3, we expect these new within-population contagion mechanisms to transmit the refashioned CVC model from early IT adopters to later IT adopters, driven by CVC programs' popularity within the IT industry, the prominence of prior IT adopters, the strategic returns accruing to IT adopters, and geographic proximity to prior IT adopters.

Popularity among peers. An innovation's popularity within a population, manifested by the number of prior adopters in the population, has been implicated in the diffusion of civil service reforms (Tolbert & Zucker, 1983), university-initiated sports programs (Washington & Ventresca, 2004), and faddish managerial innovations (Abrahamson & Fairchild, 1999). Diffusion scholars have adduced varied microprocesses linking popularity to cascades of further adoptions: neoinstitutionalists focus on mimicry in pursuit of legitimacy (DiMaggio & Powell, 1983); learning theorists focus on vicarious learning by individual decision makers or entire organizational populations (Greve, 1995; Haunschild & Miner, 1997); increasing-returns theorists focus on network externalities (Arthur, 1994); and rational-choice theorists treat popularity as an outcropping of an innovation's beneficial outcomes (Rogers, 1995).

Drawing on these persuasive arguments and evidence, we hypothesize that increases in an innovation's popularity, as reflected in the extent to which it has already diffused within an organizational population, are positively related to within-population contagion.

Hypothesis 3a. The probability of CVC program adoption by an IT firm is positively re-

lated to the number of prior adopters in the IT industry.

Prominence of similar adopters. Prospective adopters are especially likely to be influenced by the moves of more prestigious organizations within their population. Adoption of innovations involves high uncertainty, but innovations adopted by successful organizations are viewed as less uncertain, and hence are more likely to be imitated by others (DiMaggio & Powell, 1983). Prominent organizations are also regarded as worthy of imitation because of the legitimacy gains accruing from imitating them (DiMaggio & Powell, 1983; Sherer & Lee, 2002). Organization-level traits such as size and profitability are often used to infer social prominence (Fombrun & Stanley, 1990; Haunschild & Miner, 1997; Haveman, 1993). Numerous studies have reported that large and profitable firms are imitated more frequently (Greve, 1995; Haunschild & Miner, 1997; Mezias & Lant, 1994). Lant and Baum (1995) found that Manhattan hotel managers paid closer attention to the strategic actions of larger, more luxurious hotels. Other studies have reported similar results for savings and loan associations entering new markets (Haveman, 1993), choices of investment banks brokering acquisitions (Haunschild & Miner, 1997), and choices of branch location (Greve, 2000). Accordingly, we hypothesize that IT firms seek to emulate their respected peers, rendering innovations adopted by prestigious firms especially contagious.

Hypothesis 3b. The probability of CVC program adoption by an IT firm is positively related to the extent of prior adoption among prominent IT firms.

Observing peers' success. Earlier, we argued that firms notice and react to the benefits realized by adopters within the population where an innovation originated. But it would seem that firms should pay even closer attention to benefits accruing to prior adopters within their own population. Organizational learning theorists have argued that organizations learn vicariously, imitating or avoiding specific innovations on the basis of their perceived impact elsewhere (Levitt & March, 1988). Evidence for the salience of tangible benefits realized by similar others comes from Conell and Cohn (1995), who found that the success of wildcat strikes by French coal miners increased the chances of future strikes. Haunschild and Miner (1997) reported that investment bankers brokering acquisitions that generated higher returns were more likely to be retained in subsequent acquisitions. Other indirect evidence comes from studies

suggesting that favorable results achieved by earlier entrants have encouraged investors to build shipyards (Argote, Beckman, & Epple, 1990), hotels (Baum & Ingram, 1998), and nuclear power plants (Zimmerman, 1982). In sum, both logic and evidence suggest that beneficial results obtained by prior similar adopters will lead prospective adopters to anticipate similar results:

> *Hypothesis 3c. The probability of CVC program adoption by an IT firm is positively related to efficacious outcomes experienced by IT firms that are prior adopters.*

Geographic proximity to similar adopters. An axiomatic premise of diffusion theory is that proximity facilitates interaction that spreads innovations (Strang & Soule, 1998). Personal observations and communication are stronger mediators of information over short rather than long distances owing to the higher density of contacts and information spillovers (Greve, 1998). Once the assimilation of an innovation developed elsewhere has opened up the possibility of within-population contagion, proximity to other adopters within that population is likely to accelerate the innovation's transmission. Proximity facilitates "sensemaking" within communities of practice (Brown & Duguid, 1991), fuels pressures for mimetic adoption, and fosters vicarious learning through observation of innovative practices and their outcomes in similar settings. Stronger contagion effects over smaller geographical distances have been reported for such innovations as matrix management, golden parachutes, and unionization (Burns & Wholey, 1993; Davis & Greve, 1997; Hedstrom, 1994). Accordingly, we expect spatial proximity to previously adopting population members to speed an innovation's diffusion.

> *Hypothesis 3d. The probability of CVC program adoption by an IT firm is positively related to the number of proximate prior IT adopters.*

The Joint Effects of Within- and Cross-Population Contagion

We have argued that cross-population contagion exports endemic innovations to a new organizational population, and within-population contagion propagates the modified innovation within that new population. So far, our arguments have isolated the two contagion processes, focusing on the main effects of each. We now consider how these two contagion processes interact when they operate in tandem. After a formerly alien innovation mutates and becomes native, does cross-population contagion persist or does it shut down, giving way

to within-population contagion? We draw upon neoinstitutional theory to develop predictions about the joint effects of cross-population and within-population contagion, proposing that the level of "theorization" of the innovation governs the relative potency of these two effects.

Theorization of innovations. Strang and Meyer (1993) argued that diffusion is directed and accelerated by theorized accounts of the actors and practices involved in an innovation. They defined *theorization* as "the self-conscious development and specification of abstract categories and the formulation of patterned relationships such as chains of cause and effect" (Strang & Meyer, 1993: 492). The theorization of an innovative practice simplifies and abstracts its properties, explains the outcomes it produces, facilitates communication and interpretation, and thus expands and accelerates its diffusion. The fundamental claim is that "practices do not flow . . . theorized models and careful framings do" (Strang & Soule, 1998: 277).

Diffusion of well-theorized innovations entails "translating concrete practices into abstractions for export and then unpacking the abstractions into a (suitably modified) concrete practice upon arrival" (Strang & Soule, 1998: 276). Diffusion is expedited by management consultants who "arrive in organizations like traveling salesmen with attaché-cases full of quasi-objects to be translated into localized ideas" (Czarniawska & Joerges, 1990: 36). Encapsulating innovations in higher levels of abstraction accelerates the speed and reach of diffusing practices, because universal theories predict that the practices can be adopted by many or all organizations to produce similar outcomes. The spread of highly theorized innovations becomes less dependent upon proximity-induced social interaction, because theorization substitutes for direct experience and encodes practices in a "language that does not presume directly shared experience" (Strang & Meyer, 1993: 499). Conversely, innovations that are poorly or thinly theorized should diffuse more slowly, rely more heavily upon relational transmission, and encounter difficulty in breaching the boundaries of the population wherein they arose.

During the 1990s, venture capital practice was not highly theorized.[2] Venture capital practices combine VCs' tacit knowledge, expertise, and ex-

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[2] Although the venture capital *limited partnership* has become institutionalized as an organizational form (Burton, Fried, & Manigart, 2005), the underlying *practices* remain comparatively tacit, subsuming practitioners' intuition, judgment, and skills acquired and honed on the job.

perience (Wasserman, 2005). Many pioneering VCs were iconoclastic entrepreneur-investors, unable or unwilling to codify and formalize their modus operandi. Venture capitalists often dub the investments of those within their clan as "smart money"—money that comes infused with the entrepreneurial acumen, business contacts, executive talent, and patience of a financier who knows how to help young companies succeed (Doerflinger & Rivkin, 1987: 16). In contrast, an informant in our research scorned corporate venture investors as "dumb money—suckers who overpay for deals because they are in it for strategic returns." This, according to our informant, made them useful "only for goosing up your fund to show a humongous internal rate of return to snow your limited partners, and make sure they pony up for the next fund you're raising." Disdaining corporate investors as amateurs whose investment strategy was to "spray and pray," this VC deliberately avoided the theorization of his practices. A veteran corporate investor offered a complementary view:

> Private VCs are stable and they're cloaked in secrecy. It's a club that runs on trust, and that trust can be established because the half-life of your network is long. Corporate venturing is cyclical and unstable. The investors are inexperienced and naïve. At [my corporation] we've been doing this for a long time, and we've cracked the code. We've figured out how to do deals by making it simpler, and making it quicker.

Our claim that tacit knowledge underpins VC practices was substantiated by an early-stage venture capitalist:

> These relationships are literally foreign to lots of corporations. When I'm working in Silicon Valley, I know who's involved, and everybody knows what's coming next. It's like playing baseball—everybody knows the rules. But in the corporate world, the rules aren't as well understood, the players keep changing, and the team gets sold or moves unpredictably. I've waited three weeks to wrap a deal because the corporate guy who has to sign off is on safari in Africa.

Because poorly theorized venture capital practices are encoded in tacit knowledge rather than authoritative theorizations, we expect that when geographic proximity enables frequent social interaction between VCs and corporate investors, cross-population contagion will remain the prepotent mechanism driving IT corporations' CVC adoptions—more potent than the factors fueling within-population contagion. Geographic proximity fosters social relationships that have been found to increase both the speed and fidelity of tacit knowledge transfers (Greve, 2005; Jaffe et al., 1993; So-

renson & Audia, 2000). Accordingly, we expect IT firms situated near a VC cluster to tap cross-population channels in reaching CVC adoption decisions, while paying less attention to the adoption behavior, prominence, and outcomes experienced by their IT industry peers. On the other hand, we expect prospective IT adopters whose geographic isolation precludes direct and inductive examination of VCs' innovative practices to monitor their industry peers' behaviors and actions more keenly. For far-away firms, we expect within-population contagion mechanisms to predominate, with adoption chances driven by CVC programs' popularity within the IT sector, their adopters' stature, and outcomes that materialize. Stated more formally, we hypothesize that a prospective IT adopter's geographic proximity to a VC cluster will moderate the effects of within-population contagion upon the likelihood of adoption.

Hypothesis 4. IT firms that are geographically proximate to a VC population cluster are less affected by the adoption behavior of other IT firms than those that are geographically distant from a VC cluster.

METHODS

Sample and Data

To test our hypotheses, we gathered longitudinal data from a sample of U.S. firms in the information technology sector. Our data cover 264 IT firms from 1992 to 2001. Ninety-four of these firms adopted CVC programs during the ten-year time period of the study. We focused exclusively on IT firms to control for unobserved heterogeneity at the industry level, and because many of the venture capital investments during the time period of the study were made in the IT sector, rendering IT firms more likely adopters of CVC programs. The study's sample consists of IT firms drawn from the *Forbes* 500 list, which ranks U.S. firms by sales, profits, assets, and market value. Firms that rank among the top 500 on one or more of these criteria are included in the *Forbes* list, which is compiled annually. The research sample was constructed in two steps: (1) the names of all firms listed on the *Forbes* 500 between the years 1997 and 2000 were compiled, and (2) firms in the information technology sector were selected from this list. We followed the National Science Foundation's definition of the IT sector (NSF, 2000) to include firms in five industry subsectors: (1) office, computing and accounting equipment (SIC code 357), (2) communications equipment (SIC code 366), (3) electronic components (SIC code 367), (4) communication services

(SIC codes 481–484, 489), and (5) computing and data processing services (SIC code 737).

Model Estimation

We used a discrete-time event history methodology to model the adoption of CVC programs (Allison, 1982). We estimated $P_i(t)$, the conditional probability that firm i adopts a CVC program at time t. $P_i(t)$ is related to the covariates by a probit regression equation,

$$P_i(t) = \Phi[\alpha + \beta_1 x_{i1}(t) + \ldots + \beta_k x_{ik}(t)],$$

where Φ is the cumulative density function of the normal distribution and x_i's are covariates that may be time-invariant. This methodology is preferred when information on the exact timing of an event is unavailable—that is, when interval "censoring" exists (Allison, 1982). In our case, exact adoption dates are not known, since we only have annual data. A second advantage of this method is that firms that do not adopt contribute to the regression model exactly what is known about them; right-censoring is moot (Allison, 1982). Finally, time-varying explanatory variables are easily included because each period during which a firm is at risk is treated as a separate observation. Left-censoring poses no problem, since only one of the 264 firms in our sample had established a CVC program in 1991. We assumed that the cumulative density function for the error term $F(.)$ was normally distributed, so we used a probit model to estimate the probability of an adoption event in a given year, in a pooled sample consisting of each organization observed during each of the ten years.[3]

Measures

Dependent variable. Our dependent variable is the probability that a firm will adopt a CVC program at time t. To operationalize it, we relied upon the *Corporate Venturing Directory and Yearbook* for 2000, 2001, and 2002. Among other data, this directory reports the year in which firms adopt CVC programs. For confirmation and to obtain missing data, we turned to the VentureXpert database, IT firms' websites, and industry publications. In open-ended interviews, corporate venture capitalists told us that when firms make multiple direct investments in technology start-ups within a single calendar year, they nearly always house their venture capital activity within a formal structure. Following their recommendation, we treated any firm making five or more direct investments within a single year as having adopted a CVC unit in that year.[4] We confirmed that these companies had actually adopted a CVC program by examining company websites, through Lexis-Nexis searches of business press articles and venture capital newsletters, and finally, by direct communication with the companies' business development executives.

Independent variables. To test Hypotheses 1 and 2, we calculated a weighted average of geographic distance to the three main VC clusters (Silicon Valley, New York, and Route 128), and counted the number of VC-backed IPOs in the IT sector. We designated these two variables as *cross-population contagion* measures.

Silicon Valley houses the world's dominant cluster of private venture capital firms. In 2000, approximately 40 percent of all U.S. venture capital originated in Silicon Valley. The other two important regions are New York and Route 128 in New England, accounting for 12 and 11 percent of VC investment, respectively. We measured geographic *distance to VC clusters* as a weighted average of the number of miles from corporate headquarters to each of these three clusters. The weights used were the density of VC funds targeting IT start-ups in each cluster, lagged by one year. Thus, the distance of firm i to VCs at time t (d_{it}) was calculated as $d_{it} = \sum_{j=SV, 128, NY} d_{ij} \theta_{jt-1}$, where d_{ij} is the distance between firm i and cluster j (j = Silicon Valley, Route 128, or New York) and θ_{jt-1} is the proportion of VC funds in cluster j at ($t-1$) with $\sum_{j=SV, 128, NY} \theta_{jt-1} = 1$. The zip code for corporate headquarters was obtained from the *Forbes* lists. We classified the counties Alameda, Contra Costa, Marin, San Francisco, San Mateo, and Santa Clara as comprising Silicon Valley; Essex, Middlesex, Suffolk, and Norfolk as comprising Route 128; and New York, Bronx, Kings, Queens, and Richmond as comprising New York. We measured the geographic distance to each clus-

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[3] Unobserved heterogeneity leading to potentially biased estimates, a concern for all estimation techniques, is particularly problematic in event history analysis. Fixed-effects analyses have been shown to introduce inconsistent estimates (Chamberlain, 1985). In our data, random-effects estimates provide results identical to pooled estimates, with the former exhibiting higher standard errors. A test of poolability yields a *p*-value of 1, indicating that pooled probit is appropriate and that unobserved heterogeneity through the random-effects component may be ignored.

[4] We experimented by moving this threshold from five to ten investments in a single year (a more conservative parameter). This changed the CVC adoption date for 7 out of the 94 adopters but left our results unaffected.

ter as the number of miles from headquarters to the most proximate of the counties in a particular cluster, using a spherical geometry formula to calculate the distance between zip codes (Sorenson & Stuart, 2001):

$$\text{Distance in miles} = 3{,}963.0 \times \arccos[\sin(\text{zip1.lat})$$
$$\times \sin(\text{zip2.lat}) + \cos(\text{zip1.lat}) \times \cos(\text{zip2.lat})$$
$$\times \cos(\text{zip2.lon} - \text{zip1.lon})],$$

where zip *i*.lat is latitude of zip $i = 1, 2$ and zip *i*.lon is the longitude of zip $i = 1, 2$.

We measured the observed benefits of VC practices by counting the *number of VC-backed IPOs* tendered in the IT sector during the previous calendar year (Gompers & Lerner, 1998). IPOs provide an unequivocal measure of private venture capitalists' value creation. Venture capital firms' press releases herald their investing acumen by highlighting portfolio firms that have "gone public" (Gompers & Lerner, 2001b). Unlike VC firms, IT firms do not focus exclusively on financial returns, but the incidence of VC-backed IPOs indexes the returns generated by the venture capital model and signals to prospective IT adopters the potential effectiveness of VC practices in commercializing innovative technologies (Gompers & Lerner, 2001a). This measure was obtained from VentureXpert database.

Drawing upon the institutional and innovation diffusion literatures, we constructed multiple measures of *within-population contagion* influences. Specifically, we used the popularity of the innovation, prominence of prior adopters, outcomes experienced by prior adopters, and proximity to prior adopters to capture the intensity of within-population contagion (Greve, 1995; Haunschild & Miner, 1997). Prior adopters were defined as IT firms that had adopted a CVC program during or before the previous year.

Following the diffusion literature (Haunschild & Miner, 1997; Kraatz & Zajac, 1996; Rao, Greve, & Davis, 2001), we measured the *popularity of an innovation* at time *t* as the cumulated total adopters up to $(t - 1)$ in a single two-digit industry sector.[5] We limited this measure to a two-digit SIC code in view of evidence that potential adopters pay greater attention to more comparable organizations (Haveman, 1993).

As noted earlier, potential adopters also pay more attention to prior adopters that have higher status. We used the average sales of prior adopters in the same two-digit industry sector as a measure of their prominence (Greve, 2000; Haunschild & Miner, 1997; Haveman, 1993). We called this variable *prominence of prior adopters*.

Although VCs realize returns on their investments by taking portfolio companies public, corporations seek to achieve strategic returns in addition to financial returns. CVC programs enable their IT corporate parents to screen entrepreneurial start-ups at the forefront of emerging technologies that have the potential to change the competitive dynamics of the industry (Chesbrough, 2003). If a start-up proves strategically relevant, the parent firm is well positioned to acquire it. Accordingly, the rate at which firms select ventures from their CVC portfolios as acquisitions is an indicator of the vitality of CVC programs (Gompers & Lerner, 1999). We used the cumulated number of CVC-backed acquisitions as a measure of the benefits realized by adopters of CVC programs. Although CVC-backed acquisitions are not the sole strategic objective of IT firms, acquisitions are a visible and tangible indicator of the benefits accruing from their CVC programs.[6] Such acquisitions are likely to be noticed by industry peers and signal the potential value of CVC programs to prospective IT adopters. We collected these data from two sources. First, we used the Securities Data Corporation's (SDC) Mergers and Acquisitions database to obtain a list of all private acquisitions by all the CVC adopters in our sample for each of the years from 1992 to 2001. We then matched the acquisitions by each adopter with the VentureXpert database to include only those acquisition targets in which CVC adopters had invested during the time period of the study. We identified a total of 94 CVC-backed acquisitions made by the IT firms in our sample. Finally, we cumulated these acquisitions since the year of adoption to obtain a measure of beneficial *outcomes experienced by prior adopters*.

We used *proximate prior adopters* to measure the availability of innovation-related information through observation of and interaction with industry peers. For each firm at time *t*, we counted the

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[5] Using a three-digit classification left our results unaffected. A four-digit industry classification scheme proved too restrictive because very few firms were included in each four-digit classification category.

[6] Alternative measures might include the number of CVC-enabled new product introductions, returns realized from such products, and technologies licensed from portfolio companies. However, such data are not available to us, and IT firms also obtain intangible benefits from CVC programs that this measure fails to capture, such as exposure to new business models. Thus, CVC-backed acquisitions constitutes a conservative measure of the strategic benefits realized from CVC programs.

total number of adopters of CVC programs up to time $(t-1)$ in the same geographic region as the focal firm (Burns & Wholey, 1993; Davis & Greve, 1997). This procedure allowed us to distinguish proximity to CVC adopters from proximity to the VC cluster, and evaluate their relative importance in driving the adoption process.

Control variables. To isolate theorized variables' impacts upon CVC adoption, we controlled for several firm-level variables in estimating the model. As they age, organizations acquire both experience in assimilating innovations (Sorenson & Stuart, 2000) and inertia that may impede strategic change (Hannan & Freeman, 1989). To control for *age*, we counted years since a firm's founding, using *Standard & Poor's Million Dollar Directory* as a data source. Because stockpiled slack resources facilitate experimentation with innovative practices (Levinthal & March, 1981), we controlled for *slack* by including a firm's current ratio (Bourgeois, 1981), calculated from Compustat data. Past success in innovating through in-house R&D could either increase or inhibit a firm's likelihood of adopting a CVC program. Some studies have reported that internal innovation capabilities spark and complement external efforts (Cassiman & Veugelers, 2006; Dushnitsky & Lenox, 2005); others have reported that internal innovation capabilities substitute for and curb external efforts. We controlled for *innovation propensity* by counting patents awarded to a firm divided by sales (Cohen, Levin, & Mowery, 1987). We used patent application filing dates to assign a granted patent to a firm in a given year, using data compiled by Hall, Jaffe, and Trajtenberg (2001) that record all utility patents granted between January 1, 1963, and December 30, 1999.[7] Since larger firms have amassed resources that help them undertake strategic change, we controlled for firm *size* by measuring total corporate sales in the appropriate year, using Compustat data.

Next, IT firms that themselves were founded with venture capital investors may have VC practices imprinted into their organizational routines and cultures (Stinchcombe, 1965). Such firms seem

likely to have a congenital affinity for VC practices and to retain social ties to the VC community. Moreover, since VCs prefer to invest in firms located nearby (Sorenson & Stuart, 2001), these firms are likely to be headquartered near Silicon Valley, Route 128, or New York, thus confounding estimates for our primary independent variable, *geographic distance to VC clusters*. We controlled for IT firms' venture-backed origins, using an indicator variable, *VC-backed at founding*, assigned the value 1 if a firm itself was backed by private VC funding prior to its first initial public offering, and 0 otherwise, using information from VentureXpert. Finally, since a firm's decision to adopt a CVC program may be influenced by the availability of opportunities to actually make equity investments in start-ups (Ahuja, 2000; Rosenberger, Katila, & Eisenhardt, 2007), we controlled for variation in the number of such opportunities over time and across geographic settings. Using the VentureXpert database, we constructed a measure of *local investment opportunities* for each firm i headquartered in state k at time t as $\frac{n_{t-1}^{k}}{\sum_{j} n_{t-1}^{j}}$, where j is an index for states and n_{t-1}^{j} is the number of entrepreneurial startups that received VC investments in state j at time $t-1$. Table 1 provides summary statistics and correlations between the predictor variables.

RESULTS

Tables 2, 3, and 4 show the maximum-likelihood estimates of 13 models predicting CVC program adoption using a discrete-time event history model. Model 1 includes only the control variables—age, slack, innovative propensity, size, venture backing, and density of start-up deals funded in the focal firm's state. In line with earlier research on innovation (Drazin & Schoonhoven, 1996), we found that these firm-level characteristics influence innovation adoption. The negative coefficient on age indicates that younger firms are more likely to adopt CVC programs. The positive coefficients on slack and size indicate that firms with greater access to slack resources and firms with larger sales revenues were more likely to adopt CVC programs.[8] For innovation propensity, the results show that firms that generate more innovations internally (i.e., those having higher patent-sales ratios) are less likely to adopt CVC programs. Pisano (1990) reported a similar finding; firms with in-house R&D

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[7] Our study period ended in 2001, so we extended the Halle et al. data set by collecting primary data on patents granted to sample firms and their subsidiaries during 2000–2001 directly from the U.S. patent office website (http://www.uspto.gov). We used three databases (SDC's Mergers & Acquisition Database, Capital IQ, and the Directory of Corporate Affiliations) to identify the subsidiaries for all IT firms in a given year and assigned utility patents granted to these subsidiaries to the IT corporate parent.

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[8] We used assets as a measure of size as well. However, with a correlation between sales and assets of .95, it made very little difference which measure of size we used.

TABLE 1
Sample Means and Correlations[a]

Variable	Mean	s.d.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Distance to VC clusters$_{it-1}$[b]	5.07	2.41																
2. Number of VC-backed IPOs$_t$[b]	4.52	0.54	.01															
3. Popularity of innovation$_{it-1}$[b]	7.51	8.53	−.06	−.04														
4. Prominent prior adopters$_{it-1}$[b]	8.31	2.92	.13	.01	.13													
5. Outcome experienced by prior adopters$_{it-1}$[b]	−1.73	6.69	−.04	.12	.48	.24												
6. Proximate prior adopters$_{it-1}$	5.48	9.83	−.34	−.05	.56	.05	.31											
7. Popularity of innovation$_{it-1}$ × geographic distance to VC$_{it-1}$[b]	36.74	48.23	.35	−.02	.80	.13	.41	.20										
8. Prominent prior adopters$_{it-1}$ × geographic distance to VC$_{it-1}$[b]	43.01	24.74	.89	.01	.00	.55	.08	−0.27	.35									
9. Outcome experienced by prior adopters × geographic distance to VCs$_{it-1}$[b]	33.89	40.56	.37	.02	.62	.15	.52	.26	.82	.38								
10. Proximate prior adopters$_{it-1}$ × geographic distance to VCs$_{it-1}$[b]	8.87	19.62	.05	.28	.19	.04	.20	.41	.20	.06	.30							
11. Age$_{it}$[b]	2.46	1.10	−.37	0	.09	−.02	.07	.27	−.07	−.33	−.04	.15						
12. Innovative propensity$_{it}$	2.08	14.27	.25	−.01	−.10	−.02	−.14	−.10	.02	.20	.03	−.02	−.36					
13. Slack$_{it}$[b]	0.80	0.78	−.09	.01	.02	.00	.02	.06	−.04	−.08	−.01	.00	.00	−.01				
14. Size$_{it}$[b]	6.15	2.33	−.26	.06	.12	−.08	.09	.24	.01	−.26	.08	.14	.31	−.24	.11			
15. VC-backed at founding	0.52	0.50	.28	.04	−.02	.04	−.08	−.07	.10	.25	.11	.01	−.25	.64	−.10	−.34		
16. Local investment opportunities$_{it-1}$[b]	1.05	4.17	−.47	−.01	.04	−.09	.01	.32	−.15	−.44	−.15	.24	−.11	.03	.20	−.18	−.47	

[a] n = 1,726.
[b] Logarithm.

TABLE 2
Cross-Population Contagion[a]

Variable	Model 1	Model 2	Model 3
Distance to VC clusters$_{it-1}$		−0.02** (0.00)	−0.02** (0.00)
Number of VC-backed IPOs$_t$			0.57** (0.13)
Controls			
Age$_{it}$	−0.11** (0.02)	−0.10** (0.02)	−0.08** (0.02)
Innovation propensity$_{it}$	−0.02** (0.00)	−0.02** (0.00)	−0.02** (0.00)
Slack$_{it}$	0.25** (0.01)	0.25** (0.01)	0.21** (0.00)
Size$_{it}$	0.20** (0.02)	0.21** (0.02)	0.21** (0.03)
VC-backed at founding$_i$	0.04 (0.08)	0.02 (0.08)	0.04 (0.06)
Local investment opportunities$_{it-1}$	0.03** (0.01)	0.02** (0.01)	0.02** (0.01)
Constant	−2.85** (0.00)	−2.78** (0.00)	−5.44** (0.66)
Observations	1,726	1,726	1,726
Number of firms	264	264	264
Number of adoptions	94	94	94
Overall model test	62.09**	64.96**	88.05**
Joint significance test (cross population)			20.11**
df			2

[a] Standard errors are in parentheses.

** $p < .01$

One-tailed test for hypothesized variables, two-tailed for controls.

experience were less likely to move toward externalization of their innovation functions. Whether an IT firm was itself backed by VCs at time of founding does not seem to exercise a significant influence on the adoption decision.[9] Finally, availability of local investment opportunities in the focal firm's geographic vicinity increased the likelihood of CVC program adoption. The overall model test at the bottom of Table 2 is a Wald chi-square test of the joint significance of all the explanatory variables; this test shows that model 1, as a whole, is highly significant.

Cross-Population Contagion

We added the cross-population contagion variables to model 1 to get models 2 and 3. Specifically, we examined the adoption-enhancing effects upon prospective IT adopters of geographic proximity to a VC population cluster, and of observing benefits generated by VC practices. Hypothesis 1 predicted that firms exposed directly to a VC cluster due to geographic proximity would be more likely to

adopt CVC programs. In model 2 we obtained a significant and negative coefficient on geographic distance from VC clusters, showing that firms headquartered farther from a VC cluster are less likely to adopt CVC programs, while nearby firms are more likely to adopt such programs. To test Hypothesis 2, we added our measure of observed benefits of VC practices to model 3. We obtained a positive and significant coefficient, indicating that higher incidence of VC-backed IPOs escalates IT firms' adoption of CVC programs. Consequently, model 2 is a significant improvement on model 1 (Wald χ^2 = 163.98), and model 3 is a significant improvement on model 2 (Wald χ^2 = 20.11).

Within-Population Contagion

Next we investigated the effects of within-population contagion influences. Specifically, we examined how observing CVC adoptions and outcomes for other firms in the IT sector affected the likelihood of CVC program adoption by a focal IT firm.

We captured the effects on the likelihood of CVC program adoption of popularity of CVC programs, prominence of prior adopters, outcomes experienced by prior adopters, and distance to prior adopters in models 4−8 by adding variables to their baseline specification. Hypothesis 3a states that an IT firm is more likely to adopt when CVC programs gain popularity within the industry. Model 4 shows a positive and significant coefficient on the cumulative number of prior adopters in the IT industry,

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[9] In an exploratory analysis, we found that approximately 45 percent of the IT firms in our sample had been venture backed. Thus, restriction of range on this variable may be one reason for its insignificance. To check whether adoption by IT firms headquartered far from a VC cluster was affected by VC backing at the time they were founded, we reran the analysis for a subsample of distant IT firms, and found no effect.

TABLE 3
Within-Population Contagion[a]

Variables	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Distance to VC clusters$_{it-1}$						−0.02† [0.01]
Number of VC-backed IPOs$_t$						0.39** [0.15]
Popularity of innovation$_{it-1}$	0.02** (0.00)				0.01** (0.00)	0.01** (0.00)
Prominent prior adopters$_{it-1}$		0.05** (0.00)			0.02** (0.00)	0.02** (0.00)
Outcomes experienced by prior adopters$_{it-1}$			0.04** (0.00)		0.03** (0.00)	0.02** [0.01]
Proximate prior adopters$_{it-1}$				0.06** (0.00)	0.04** (0.00)	0.03** [0.01]
Controls						
Age$_{it}$	−0.09** [0.02]	−0.10** [0.02]	−0.09** [0.02]	−0.08 [0.02]	−0.07** [0.02]	−0.06** [0.02]
Innovation propensity$_{it}$	−0.02** [0.00]	−0.02** [0.00]	−0.02** [0.00]	−0.02** [0.00]	−0.02** [0.00]	−0.02** [0.00]
Slack$_{it}$	0.23** [0.01]	0.25** [0.01]	0.21** [0.01]	0.20 [0.01]	0.18** [0.01]	0.19** [0.01]
Size$_{it}$	0.21** [0.02]	0.20** [0.02]	0.21** [0.02]	0.20 [0.02]	0.21** [0.02]	0.21** [0.03]
VC-backed at founding	0.02 [0.01]	0.03 [0.09]	0.04 [0.08]	−0.08 [0.05]	−0.06 [0.05]	−0.02 [0.03]
Local investment opportunities$_{it-1}$	0.03* [0.01]	0.03** [0.01]	0.03** [0.01]	0.01 [0.01]	0.01† [0.01]	0.02** [0.01]
Constant	−3.11** [0.02]	−3.23** [0.01]	−2.89** [0.03]	−2.93** [0.01]	−3.18** [0.03]	−4.98** [0.72]
Number of observations	1,726	1,726	1,726	1,726	1,726	1,726
Number of firms	264	264	264	264	264	264
Number of adoptions	94	94	94	94	94	94
Overall model test	84.0**	61.92**	83.62**	90.65**	98.26**	105.85**
Joint significance test (within population) $df = 4$					45.74**	26.76**
Joint significance test (cross population) $df = 2$						15.54**

[a] Standard errors are in parentheses.
† $p < .10$
** $p < .01$
One-tailed test for hypothesized variables, two-tailed for controls.

TABLE 4
Cross Versus Within-Population Contagion[a]

Variable	Model 10	Model 11	Model 12	Model 13
Distance to VC clusters$_{it-1}$	−0.04** (0.00)	−0.12** (0.03)	−0.04** (0.01)	−0.04** (0.00)
Number of VC-backed IPOs$_t$	0.53** (0.12)	0.56** (0.12)	0.48** (0.12)	0.48** (0.14)
Popularity of innovation × distance to VC clusters$_{it-1}$	0.00** (0.00)			
Popularity of innovation$_{it-1}$	0.02** (0.00)			
Prominent prior adopters$_{it-1}$ × distance to VC clusters$_{it-1}$		0.01* (0.01)		
Prominent prior adopters$_{it-1}$		0.00 (0.02)		
Outcomes experienced by prior adopter$_{it-1}$ × geographic distance to VCs$_{it-1}$			0.00* (0.00)	
Outcome experienced by prior adopter$_{it-1}$			0.03** (0.00)	
Proximate prior adopters$_{it-1}$ × distance to VC clusters$_{it-1}$				0.01** (0.00)
Proximate prior adopters$_{it-1}$				0.00** (0.00)
Controls				
Age$_{it}$	−0.07** (0.02)	−0.07** (0.02)	−0.07** (0.02)	−0.08** (0.02)
Innovation propensity$_{it}$	−0.02** (0.00)	−0.02** (0.00)	−0.02** (0.00)	−0.02** (0.00)
Stack$_{it}$	0.20** (0.00)	0.23** (0.01)	0.17** (0.01)	0.17** (0.01)
Size$_{it}$	0.22** (0.04)	0.21** (0.03)	0.21** (0.03)	0.19** (0.03)
Venture backed at founding$_i$	0.02 (0.06)	0.05 (0.07)	0.03 (0.07)	−0.01 (0.03)
Local investment opportunities$_{it-1}$	0.02** (0.01)	−0.04* (0.02)	0.03** (0.01)	0.01 (0.01)
Constant	−5.49** (0.70)	−5.33** (0.74)	−5.03** (0.68)	−4.89** (0.75)
Observations	1,726	1,726	1,726	1,726
Number of firms	264	264	264	264
Number of adoptions	94	94	94	94
Overall model test	96.68**	89.58**	100.88**	96.63**

[a] Standard errors are in parentheses.
* $p < .05$
** $p < .01$
One-tailed test for hypothesized variables, two-tailed for controls.

supporting Hypothesis 3a. Hypothesis 3b argues that potential adopters tend to pay more attention to prominent prior adopters. Model 5 supports Hypothesis 3b by showing that prior adopters' prominence has a positive and significant influence on the adoption of CVC programs. Model 6 confirms Hypothesis 3c's prediction that success is contagious—when IT corporations acquire start-ups funded by their own CVC programs, other IT firms are encouraged to adopt. Model 7 shows that adoption by peers in close geographic proximity to a focal firm increases its probability of adoption, offering support for Hypothesis 3d. Finally, model 8 includes all the within-population contagion variables and confirms the results of the earlier models. We found that prospective adopters are influenced by the popularity of CVC programs in their industry, by prior adopters' prominence, by the outcomes experienced by prior adopters, and by proximate prior adopters. A Wald chi-square (45.74) comparing models 1 and 8 indicates a significant improvement in model fit. Our results are consistent with those reported in prior studies examining

the within-population contagion influences on the adoption of new organizational practices (e.g., Greve, 1995; Haunschild & Miner, 1997).

Finally, in model 9 we included both cross- and within-population influences on the probability of innovation adoption. A Wald chi-square (15.54) comparing models 8 and 9 indicates a substantial improvement in model fit. To compare the effects of cross- and within-population contagion, we calculated the magnitudes of the influences of the variables in model 9. We evaluated the marginal effects at the means of the independent variables. The two variables with the most powerful effect on CVC program adoption were geographic distance from VC clusters and the observed benefits of VC practices—the cross-population contagion variables. A 1 percent increase in distance cut the probability of CVC program adoption by 0.04 percent, and a 1 percent increase in observed benefits of VC practices boosted the probability of adoption by 0.9 percent. In contrast, our within-population contagion variables had a substantially smaller influence. A 1 percent increase in the within-industry

popularity, prominence, outcome, and proximity variables raised the probability of CVC program adoption by 0.03 percent, 0.04 percent, 0.04 percent, and 0.06 percent, respectively. Clearly, our estimation models indicate that cross-population influences are significant from both a statistical and substantive point of view, and that ignoring them would offer at best a partial view of diffusion dynamics. In sum, our results suggest that in addition to the more familiar within-population contagion mechanisms, cross-population contagion triggers other powerful mechanisms galvanizing IT firms to adopt CVC programs.

When Cross- and Within-Population Contagion Interact

Next, we examined the role of geographic distance to the VC population in moderating the potency of within-population contagion influences. Hypothesis 4 predicts that firms geographically proximate to a VC population cluster are less subject to influences arising from the actions and outcomes of prior adopters within their own industry. Accordingly, we tested Hypothesis 4 by interacting within-population contagion measures with geographic distance to VC clusters.

In model 10, we obtained a significant negative coefficient for distance to the VC clusters and a significant, positive coefficient for the interaction term. This finding suggests that IT firms that are geographically distant from a VC cluster are heavily influenced by the popularity of CVC programs in their industry, whereas proximate IT firms are inclined to ignore their peers. In other words, the impact of the within-population popularity of CVC programs upon the probability of adoption is contingent on proximity to a VC cluster, with proximate firms discounting popularity-based contagion influences in making adoption decisions.

In model 11, we interacted prior adoption by prominent IT firms with geographic distance to the VC clusters. The coefficient on distance is negative and significant, and the interaction term is positive and significant, suggesting that geographically distant firms are more susceptible to the actions of prominent prior adopters within their industry. This finding supports our prediction that IT firms proximate to a VC cluster discount the actions of prominent firms within their industry.

In model 12, we interacted outcomes experienced by prior corporate adopters with distance to VC clusters. As in models 10 and 11, we found that the coefficient for the interaction term is positive and significant. This suggests that firms that are distant from the main VC clusters pay close attention to the outcomes experienced by prior adopters within their industry, and firms located near VC clusters are less affected. So here too, geographic proximity moderates the effect of within-population contagion upon the likelihood of CVC program adoption.

In model 13, we interacted proximate prior adopters with distance from VC clusters. The results show that, as hypothesized, IT firms geographically distant from a VC cluster were less likely to adopt CVC programs, and that they were more susceptible to contagion from an increase in the number of IT adopters in their close vicinity. In sum, our results show that at least within the context we studied, firms were differentially susceptible to the actions and experiences of their industry peers. Firms located near the originating VC population were less susceptible to within-population contagion influences.

DISCUSSION AND CONCLUSION

In this article, we have proposed and tested a midrange theory explaining the incursion of venture capital practices into the information technology sector of the U.S. economy, and their subsequent diffusion in the form of corporate venture capital programs. In the 1950s, enclaves of private venture capital investors devised a set of innovative approaches to identifying promising entrepreneurial start-ups, accelerating them through their early developmental stages, and helping them achieve liquidity. In the 1960s, alarmed by VC-backed start-ups' forays into their product-markets, public corporations tried to emulate the VC model, expecting strategic renewal and financial returns to follow (Gompers, 2002). But 1960s-style corporate venturing proved ineffectual, so most programs were terminated and the venture capital model beat a retreat to Sand Hill Road and Route 128. In the 1990s, corporate interest in the VC model was reignited by stellar performances of VC-backed firms in the technology sector and by corporations' growing disenchantment with traditional R&D programs. VC practices once again infiltrated publicly traded corporations, this time undergoing more extensive modification. Corporate venture capital programs diffused rapidly in the 1990s and were found to yield better results, on average, than private venture capital investments (Gompers, 2002).

We conceptualized the slow and faltering spread of VC practices as a specific instance of the diffusion of an endemic innovation—one that, at the outset, is exclusively native to its organizational population of origin. We argued that endemic innovations spread into adjacent organizational popu-

lations through two different forms of contagion. The first, cross-population contagion, flows through close interpersonal relations that afford direct exposure to the innovation, observation of its tangible payoffs, and inductive learning of its innovative practices. We reasoned that cross-population contagion requires protracted interpersonal contact, because the initial transfer of an endemic innovation entails the appropriation of tacit knowledge and its recombination and application in an alien organizational setting.

We tested hypotheses based on this argument by collecting longitudinal data from 264 information technology corporations from 1992 through 2001. Event history analyses provided support for our predictions. Results suggest that IT firms' managers learned and appropriated venture capital practices through direct contact with VC partners and interpreted the rate of venture-backed IPOs as tracking the value created by VC practices. Our cross-population findings suggest that personal relationships and physical proximity facilitate the transmission of an endemic innovation into a new population.

We further theorized that a second set of diffusion mechanisms starts to operate once an endemic innovation takes root in the new setting. Contagion within the new population begins, supplementing without necessarily supplanting the initial cross-population contagion process. We reasoned that diffusion among a single industry's more culturally homogeneous firms would rely less on direct relationships fostered by close physical proximity to VCs, and would rely more on mimicry and social comparison processes. Our results support these conjectures. They suggest that the popularity of CVC programs within the IT industry, the proximity and prominence of IT firms adopting prior programs, and signals that the programs were paying off for their corporate parents by generating attractive acquisition targets fueled the diffusion of corporate venturing programs in the 1990s. These findings are consistent with those of previous research, and they suggest that prior diffusion theories and results are especially germane to the spread of innovations within sets of culturally similar organizations.

Finally, we considered how cross-population diffusion and within-population diffusion mechanisms interact. We reasoned that cross-population contagion remains prepotent whenever a prospective adopter's physical proximity to members of an innovation's originating population allows direct contact with the innovation's practices and practitioners. In the absence of physical proximity, we predicted that within-population contagion would have a greater impact on adoption behavior. Our findings support these expectations: the more distant a prospective IT adopter's headquarters from a VC cluster, the more closely the firm's adoption decisions were aligned with its IT industry peers. These results suggest that where propinquity allows cross-population contagion mechanisms to operate, they are more potent than within-population mechanisms. Among IT corporations, increases in the observed rates of VC-backed IPOs had the strongest impact upon IT firms' adoption of corporate venturing, followed by proximity to a VC cluster. These two diffusion mechanisms appear to have overwhelmed the effects of the within-population mechanisms that have been the focus of much previous work.

Implications for Theory and Research

Our investigation of corporate venture programs has implications for the study of organizational fields and for theories of innovation diffusion. First, the study's results underscore the value of mechanism-based theorizing, taking the organizational field as the fundamental unit of analysis (Davis & Marquis, 2005). In particular, they show the value of moving beyond single-population research samples to consider the social mechanisms connecting the different organizational populations that inhabit a field (Meyer et al., 2005). Second, our analyses illustrate how innovations penetrate organizational population boundaries—an issue seldom explored in the innovation diffusion literature. By explicitly delineating cross- and within-population contagion mechanisms, we offer a more complete and nuanced analysis. The study highlights the endemic character of certain innovations and the role that weak theorization plays in sequestering an endemic innovation within the population where it originated (Strang & Meyer, 1993). Like a user-friendly instruction manual, careful and comprehensive theorization makes adopting an innovation seem imaginable and sensible in a new population. Third, the study shows that geography proximity to the originating population is crucial to the diffusion of an endemic innovation. Direct communication, overlapping personal and professional relationships, interpersonal trust, and reputational capital are critical in absorbing uncertainty about innovations whose practices are enigmatic and poorly theorized. Fourth, our study shows that innovations that generate tangible benefits are especially contagious. Strang and Macy observed that "while much work emphasizes the impact of *adoptions* elsewhere, there is little attention to the *results* experienced by others" (2001: 153; emphasis in original). Such theories imply that "firms imitate

blindly, attending to popularity rather than performance" (Strang & Macy, 2001: 155). Our results suggest that an innovation's payoffs matter.

Our research has limitations. Conclusions drawn from studying information technology corporations' adoptions of corporate venturing programs should be extrapolated cautiously to firms in other industries and to firms adopting other kinds of innovations. Our findings may be influenced by unique features of the innovation we studied. CVC programs are especially reliant upon tacit knowledge, in part because venture capitalists avoid codification of their practices. Thus, our results may not generalize to innovations that are more thoroughly theorized or that embody less complex and less skilled practices. Future research should examine how theorization and proximity contribute jointly to adoption decisions. Does geographic proximity accelerate the diffusion of all innovations, or only those that are poorly theorized and administratively or technically complex? More importantly, how does all of this affect firm performance? Do firms that adopt a CVC program as a consequence of proximity to a VC cluster achieve a deeper understanding of the VC model and obtain superior results? This question could be explored by comparing the strategic and financial returns generated by proximate and distant CVC programs. It could also be addressed by studying program abandonment: If direct access to VC practitioners and practices translates into higher-fidelity corporate reproduction of the VC model, then proximate CVC adopters should retain their programs longer. Finally, our work has examined the role that *organizational* populations play in diffusion. Future research might investigate whether our results are replicated during diffusion among other sorts of populations, including those formed by shared language, values, or nationality. A colleague posed the following thought-provoking question: "I wonder whether it was harder to successfully take VC to IT or to Asia?"[10]

This article is about high-tech firms seeking to rejuvenate their product offerings, renew their business models, and disrupt their competitors' technologies by adopting innovative venturing practices. Given all the furor over innovation and upheaval, it is worth noting that our study's central finding is a time-honored truism. Even in a world of digital information, outsourced work, distributed decisions, and global supply chains, it is reassuring to discover that innovative approaches to innovating still spread best when people in richly connected social networks come into direct physical contact, get acquainted, and exchange analog data.

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[10] We thank an anonymous reviewer for posing this question.

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