Economic Geography 81(2): 201–228, 2005.

Entrepreneurial Geographies: Support Networks in Three High-Technology Industries

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Abstract: Using a unique database derived from prospectuses for U.S. initial public stock offerings, we examine the location of four actors (the firm's lawyers, the venture capitalists on the board of directors, the other members of the board of directors, and the lead investment banker) of the entrepreneurial support network for startup firms in three high-technology industries: semiconductors, telecommunications equipment, and biotechnology. We demonstrate that the economic geography of the biotechnology support network differs significantly from the networks in semiconductors and telecommunications equipment. Biotechnology has a far-more-dispersed entrepreneurial support network structure than do the two electronics-related industries. The case of biotechnology indicates that if the source of seeds for new firms is highly dispersed, then an industry may not experience the path-dependent clustering suggested by geographers. We argue that contrary to common belief, biotechnology and its support network do not exhibit as great a clustering as do semiconductors and telecommunications equipment and their support networks. This argument leads to an epistemological issue, namely, the lack of interindustry comparative work. This is an odd omission, since nearly all authors agree that industries are based on particular knowledge bases, yet few consider that the knowledge and the sources of it may have an impact on spatial distributions.

Key words: biotechnology, semiconductors, telecommunications, clusters, high technology.

In the past two decades, the quest to gain a better understanding of the spatial dimensions of innovation and entrepreneurship has attracted not only geographers, but also economists, sociologists, and business-school researchers (for a comprehensive review and synthesis of thinking about entrepreneurship in the social sciences, see Thornton 1999). Motivated by Alfred Marshall's (1890) original observation that related economic activities are often concentrated within certain locales that have been variously termed clusters or industrial districts, researchers, such as Piore and Sabel (1984), Malecki (1980), Storper (1995), and Krugman (1991), have placed clusters at the

The authors gratefully acknowledge the support of the University of California Office of the President's Industry-University Cooperative Research Program, although the office bears no responsibility for any of the data or conclusions. The authors thank Olav Sorenson for providing data on the location of biotechnology firms and Sharmistha Bagchi-Sen, Amy Glasmeier, Allen Scott, and the three anonymous reviewers for their comments and encouragement.

center of a newly revived economic geography. Scholars now agree that spatially localized, economically significant synergies of various sorts exist (Markusen 1996; Porter 1998; Storper and Walker 1989; Scott 1988). Furthermore, the literature has come to recognize that regional concentrations of economic activity can encourage entrepreneurship and innovation.

Cluster studies have explicitly recognized horizontal clustering (between competing firms) and vertical clustering (between separate segments of the value chain, such as a supplier and an assembler) (in economic geography, see such classic texts as Storper and Walker 1989 and Perroux 1988). With the exception of venture capitalists, less attention has been given to the other actors in entrepreneurial clusters that assist entrepreneurs in creating a new firm. In this article, we term these actors constituents of an "entrepreneurial support network." Although the literature has clearly noted the importance of local business services (Porter 1998; Bennett, Graham, and Bratton 1999; Muller and Zenker 2001; Scott 2002), it is remarkable that there have been few quantitative studies of the location of business services that support entrepreneurship (for a general critique of the lack of quantitative studies in geography, see Markusen 1999). The common assumption is that these services are highly clustered in close proximity to the startup. This article explores this assumption by examining four constituents of the support network: law firms, venture capitalists on the firms' boards of directors, investment bankers, and the independent members of the firms' boards of directors in three industries: semiconductors, telecommunications equipment, and biotechnology.

The importance of these entrepreneurial support networks has long been recognized (Kenney and von Burg 1999; Saxenian 1994) and been variously termed a "social structure of innovation" (Florida and Kenney 1988), an "ecosystem" (Bahrami and Evans 2000), an "incubator region" (Schoonhoven, Eisenhardt, and Lyman 1990), or a "habitat" (Lee, Miller, Hancock, and Rowen 2000). For a variety of reasons, most quantitative studies of these networks have concentrated on individual constituents of the network, such as venture capitalists (see, e.g. Bygrave and Timmons 1992; Florida and Kenney 1988; Sorenson and Stuart 2001) or law firms (Suchman 2000). Using the data from all semiconductor, telecommunications equipment, and biotechnology firms that made an initial public stock offering (IPO) from mid-1996 through 2000, we examine the location of four different constituents of a startup's network. While venture capitalists have received the most attention, the location of other constituents of the support network, including investment bankers, accountants, or persons who are capable of serving on the startup's board of directors, has received far less attention.

Previous research has invariably focused on only one constituent of the entrepreneurial support network or examined the constituent with insufficient attention to the actual industries within which the startup operates despite the wide recognition that other characteristics of high-technology industries, such as semiconductors and biotechnology, differ significantly (Cohen and Walsh 2002; Lim 2004; Swann and Prevezer 1996). The high-technology industry that has received the most attention with regard to its spatial configuration is biotechnology (Powell, Koput, Bowie, and Smith-Doerr 2002; Zucker, Darby, and Torero 2002; Romanelli and Feldman 2004), although Zook (2002) examined the regional distribution of venture capital and Internet startups, and Angel (1989) and Almeida and Kogut (1999) studied semiconductors. This article extends previous research by comparing the spatial configuration of the support networks in three different industries at a similar time in a firm's life cycle, namely, at the moment of its IPO.

The startups in these three industries exhibit similar outward characteristics. That is, they are innovation driven, entrepreneurship is a significant path for the commercialization of innovations, startups can attract significant sums of venture

capital, the startups aim to grow rapidly, and the startups are structured to achieve significant capital gains by having a liquidity event in the form of either being acquired or offering stock to the public.

Here, we examine three puzzles: First, do different high-technology industries exhibit similar clustering patterns? Second, is the spatial configuration of the entrepreneurial support-networks similar in all three industries? Third, are there systematic differences by industry in the proximity of the support network constituents to the startup? If there are differences, can hypotheses be advanced that may explain these differences?

This article has a complicated structure because it examines four actors in three industries. To simplify the discussion, each industry is discussed separately, and then the interindustry comparisons are presented. We begin by reviewing the general literature on entrepreneurial clusters and entrepreneurial support networks. Studies related to a single industry are discussed in the industry sections. The second section describes the four constituents of the support network. The third section describes the database and discusses its strengths and limitations. The fourth section discusses the three industries in the following order: semiconductors, telecommunications equipment, and biotechnology. The fifth section directly compares and contrasts the entrepreneurial support networks in the three industries. In the discussion and conclusion, we reflect on how this study contributes to the literature on high-technology clustering and what it suggests about entrepreneurial support networks, and note the importance of cross-industry research designs.

Previous Research

The regional clustering of economic activity and the entrepreneurship involved in the formation of new firms is widely recognized as a socially embedded activity (on social embeddedness, see Granovetter 1985; on the embeddedness of economic activity in a regional context, see Storper and Salais 1997). In regions with a high incidence of the formation of new firms, various institutions have arisen to facilitate the establishment of firms. The interplay of entrepreneurs who are launching firms and the establishment of networks of institutions that are dedicated to assisting such startups has helped produce regions that are characterized by the rapid development of innovations.

Silicon Valley is often considered the ideal-typical innovative region, and many have credited its networks of organizations and individuals that are dedicated to assisting startups as being an important factor in the region's innovative vitality (Bahrami and Evans 2000; Castilla, Hwang, Granovetter, and Granovetter 2000; Cohen and Fields 2000; Kenney and von Burg 1999; Lee, Miller, Hancock, and Rowen 2000; Saxenian 1994). Such concentrations of activity are most frequently referred to as "clusters" or "industrial districts," and in the past decade, the relationship among innovation, entrepreneurship, and the geography of these clusters has attracted the attention of academics from a variety of disciplines.

Within clusters, technological knowledge spills over to such an extent that Marshall (1890, 271) observed that within them, "the mysteries of the trade become no mysteries; but are as it were in the air." Numerous studies have demonstrated that knowledge spillovers are geographically mediated, which is to say that innovation appears to be concentrated in clusters (Florida 1995; Maskell and Malmberg 1999; Storper 1994). As early as 1980, Malecki observed that there was regional variation in research and development (R&D) and argued that there were significant differences between the levels of innovation in different regions. Feldman (1994) found that innovative activity in particular industries was concentrated in different locations. For example, in California and Massachusetts, there were high concentrations of innovative electronics, while in New Jersey and New York, there were concentrations of medical instruments. This clustering of innovation is not just a result of production clustering, for even after the geographic concentration of production

is accounted for, innovations are more likely to cluster geographically in industries where R&D, skilled labor, and university research are important inputs (Audretsch and Feldman 1996).

The regional concentration of innovation was shown by Jaffe, Trajtenberg, and Henderson (1993), who found that patents cited other patents that originated in the same location more frequently than they cited patents that originated from outside the location, even after the existing geography of related research activity was controlled. This methodology has been extended by others (Almeida and Kogut 1997; Breschi and Lissoni 2002) with similar results; patent citations in many fields are highly localized, indicating that there are spatial effects that can limit knowledge spillovers. There is some evidence to suggest, however, that patent citations in biotechnology may not be so geographically localized (Owen-Smith and Powell 2004).

Various reasons have been given for why there are geographic limits on the ability of such knowledge to be transmitted. One such explanation is that cutting-edge knowledge is tacit in nature, is therefore difficult to transmit, and relies upon face-to-face interaction to be transmitted effectively (Feldman 2000). Such knowledge is "sticky" and does not easily spread beyond the setting in which it is applied. Because the transmission of tacit knowledge requires face-to-face interaction among individuals, such knowledge is frequently embedded in a spatially proximate social setting. Indeed, Brown and Duguid (2000) suggested that such knowledge travels from firm to firm within a cluster through networks of shared practice within which interpersonal interaction is the conduit. Pinch and Henry (1999) used the concept of a community of knowledge to describe the untraded means of disseminating information that are found in the British motor sport industry. It is networks that provide the transmission routes for the knowledge that is exchanged within a cluster, and because social relations maintain these networks, they are apt to be limited geographically. Networks are conduits for more than just tacit technological knowledge; they also transmit specialized market information. Equally significant is the fact that personal reputation is a product of these networks.

The mix of such networks and institutions in Silicon Valley has been referred to variously as a "social structure on innovation," an "incubator region," and an "ecosystem" (Florida and Kenney 1990; Schoonhoven and Eisenhardt 1989; Bahrami and Evans 2000). The constituents of this ecosystem may include such specialized actors and institutions as universities and research institutes, venture capitalists, law firms, executive search firms, business consultants, accountants, and investment banks. All these actors assist in the operation and creation of firms, and, as such, they fit Marshall's (1980) second of three distinct reasons why entrepreneurship may be expected to be clustered, namely, to have access to specialized inputs and services that are available in the region (see Krugman 1991, 36–54, for a detailed discussion of Marshall's reasons for why firms cluster).

Among the members of this entrepreneurial support network, only the spatial distribution of venture capitalists has been subject to rigorous quantitative investigation. Sorenson and Stuart's (2001) study of the spatial dimensions of venture capital investment demonstrated that although the bulk of venture capital investing is local, experienced venture capitalists exhibit more dispersed co-investment patterns not only geographically, but also industrially. They attributed this result to the fact that network relationships among venture capitalists, as evidenced by prior syndication experience, diminishes the spatial limitation on the flow of specialized information. In a study of venture financing and the Internet industry, Zook (2002) found that the presence of venture capital investments in a region was significantly and positively associated with the entry of Internet firms to that region. In this case, the perceived need for rapid entry into the Internet industry placed a premium on access to the resources that venture capitalists possess.

Previous research emphasized the role of networks as a means of transmitting specialized market information and providing services to startups, although, as Markusen (1999) noted, there has been insufficient quantitative research on the networks in these innovative regions. Our study extends previous quantitative work that focused solely on venture capital by examining three other constituents of a startup's entrepreneurial support network, measuring the proximity of actors in these networks, and providing a comparison among different industries.

The Constituent Actors of an Entrepreneurial Support Network

The actors in the entrepreneurial support network derive their sustenance from the entrepreneurial firms they support. The literature suggests that there should be positive feedback loops or nonergodic path development as successful startups encourage the growth and elaboration of the support network, and vice versa (Arthur 1994; Storper and Walker 1989). The larger the cluster of startups and the more concentrated it is spatially, the greater the number and variety of support-network actors one would expect within the region. Moreover, if an industry requires specific knowledge to evaluate the startups, one would expect the support network to be more highly clustered in the region with the greatest number of startups drawing upon that specific knowledge base. The most established entrepreneurial support networks can exhibit a complicated division of labor, including financial intermediaries of various sorts, law firms, accountants, contract manufacturers, and a myriad of specialized consultants. This article examines the following four significant constituents of the entrepreneurial support network: law firms, venture capitalists, lead investment bankers, and other independent members of the board of directors. In this section, we briefly describe these constituents roughly in their order of assistance to the startup.

Law Firms

Often the first person whom entrepreneurs consult is a lawyer who assists in incorporation, dealing with intellectual property, the proper procedures for separating from previous employers, and the myriad of other issues that any young firm faces. In entrepreneurial, high-technology regions, lawyers are often intimately involved in startups from their inception (Suchman 2000). Because of the intimate role that the law firm plays in a startup, one would hypothesize that a law firm would be located in close proximity to its startup client. It is more difficult to predict the location of the law firm for startups that are established outside entrepreneurial clusters because the local law firms have little expertise in assisting high-technology startups, which may encourage such startups to retain law firms from one of the entrepreneurial clusters.

Venture Capitalist Board Members

Venture capitalists are intermediaries who are willing to invest capital in a risky new venture. Because their stake in the firm is in the form of equity, they are actively involved in monitoring their investment. Often they assist in recruiting executives and provide introductions to possible suppliers, customers, strategic partners, investment bankers, and investors (Bygrave and Timmons 1992; Florida and Kenney 1988; Gilson and Black 1998; Gompers and Lerner 1999; Lerner 1995). To undertake these roles, venture capitalists must be embedded in a network that provides information on a wide variety of relevant issues. To survive, experienced venture capitalists have developed an informed capability to assess the value and likelihood of success of potential investments. Indeed, the venture capital industry shares many aspects with early financial-market communities (Greenwald and Stiglitz 1992) and contemporary corporate banking (Uzzi 1999) in that the human networks within which information is transmitted are vital to the success of a business. Because venture capital firms operate

in a tightly knit community and have detailed information on the projects they fund and the industries in which their entrepreneurs operate, there is a strong reliance upon trust and reputation in the relationship between venture capitalists and the firms they fund (Gompers and Lerner 1999). Because of their monitoring function, we believe that venture capitalists are likely to be local.

Investment Bankers

The role of investment bankers comes somewhat later in the life cycle of a startup and, in the case of this study, pertains to their activities in organizing the IPO of a firm. The lead investment banker organizes the "roadshow" in which the top executives of the firm present their firm to institutional investors, arrange the syndicate of brokers that will market the stock, and handle the details of filing the proper papers with the U.S. Securities and Exchange Commission (SEC). Often, however, their role goes further in that they can advise the firm on the timing of the IPO and on various other financing options. Historically, the largest and most prestigious investment banks, such as Goldman Sachs and Morgan Stanley, have been headquartered in New York City, although in the 1970s and 1980s, a number of smaller boutique investment banks, such as Hambrecht and Quist, Robertson Stephens, and Montgomery Securities (which were acquired by larger outside banks during the 1990s) were established in San Francisco with the express purpose of providing high-technology startups with assistance on financing. The Boston area also has a number of local investment banks that specialize in high technology. During the 1990s, the small San Francisco boutique investment banks were acquired by nonlocal banks, and the largest New York City investment banks established operations in Silicon Valley to ensure their access to flows of deals (Kenney and Patton 2004; Rogers and Larsen 1984; Borrell 2001). Because of the concentration of investment banks in Silicon Valley and Boston, we would expect that local investment banks would serve the startups in those regions. On the other hand, it may be expected that startups outside Silicon Valley would be served by banks from New York.

Nonventure Capitalist Board Members

The nonventure capitalists on the startup's board of directors are a diverse group and may fulfill a variety of different roles. For example, they may be appointed because of their specific technical knowledge or business acumen; in these cases, the networks within which they are embedded are important. At other times, they may be executives at firms that are or could become either customers or suppliers, thereby facilitating or cementing a relationship. In some cases, they may be appointed to the board simply because of their reputations. These directors are a polyglot group, including corporate executives, university professors, former corporate executives, lawyers, and other professionals. Given the variety of roles they discharge, it may be expected that they would be more geographically dispersed than the other actors would be.

Data and Methodology

The data used in this article were drawn from the S-1 registration statement and the 424B prospectus that every firm that wants to issue an IPO must file with the SEC. These are the most accurate data that are available to scholars because falsification of the filings is a federal offense. Included in these documents are information on the firm; its industry; its lawyer; its investment banker and the investment banker's lawyer; and the names of its board members, including key venture capitalists and other independent board members.[1]

[1] We also have information on the startup's accounting firm, but we do not have the names and addresses of the lead accountants who were responsible for the startup. Therefore, we could not locate the relevant office, although anecdotal information suggests that it is usually in close proximity to the startup.

These documents provide a snapshot of the firm at the time that it went public.

The unavoidable shortcoming of the data is that they are available for only a small number of the total firms that are formed in an industry because only a small number of firms ever mature to the point of being able to issue an IPO. Therefore, the firms that we studied are the most successful startups, and this censoring means that they are not representative of all startups in these industries. The period we examined was one during which there was an enormous stock market "bubble" that affected all electronics and information technology firms and, to a far lesser degree, biotechnology. It is difficult to say how the bubble affected the spatial distribution, although it is plausible that it created greater dispersion in the industries that were the most highly affected—in this case, the telecommunications equipment firms. However, as Table 1 indicates, our population exhibits roughly comparable spatial distributions to populations that include all startups.

Despite the geographic similarity, it can still be questioned how representative our sample is of the entire population of startups in these three industries. This question is difficult to answer because the detailed quality of data available for public firms is not usually available for private firms. In one of the few studies that differentiated between startups that received and did not receive venture capital, Burton, Sørensen, and Beckman (2002) showed that the management team's graduation from elite research universities had a significant positive effect on the ability to attract venture capital. We believe that, on average, firms with higher-quality management teams, more venture capital from better venture capitalists, and the like were more likely to go public. In sum, regarding the other characteristics of the entire population of startups, we cannot be sure, but in geographic terms, we are quite confident.

The addresses of the firms and their lawyers were in the filings. Although we have the name of the investment banks, the filings did not contain the names or addresses of the lead investment bankers. Because we were unable to obtain the names of the lead investment bankers and because many investment banks have multiple offices, there was no obvious criterion by which to attribute an investment banker to an office. To overcome this problem, we collected anecdotal information on particular deals by investment bankers and then compared their location with that of the investment banks' law firms, as stated in the prospectuses. The law firm's location proved to be a strong proxy for the lead investment banker's regional location. Thus, all the locations for the investment bankers are those of their proxies, the law firms.

The SEC requires each prospectus to include a list of its executives and board of directors. This information yielded a list of the independent board members that was parsed into two mutually exclusive sets: the board members who were affiliated with venture capital firms and the remaining board members who were not venture capitalists. The addresses and locations of all board members were found in the prospectuses and through Internet searches. Less than 5 percent of the board members who were venture capitalists could not be located. Precise addresses were also found for 95.6 percent, 86.9 percent, and 81.9 percent of board members who were nonventure capitalists in semiconductors, communications, and biotechnology, respectively.[2] The rosters of the firms in this study were obtained from the VentureXpert database's listing of IPOs from June 1996 through 2000. The database does not include small businesses

[2] As a methodological note, for the venture capitalists our research is more accurate than previous research because we can attribute the individual venture capitalist to the actual office, whereas scholars who have used the VentureXpert database have attributed the investment to the venture capital firm's headquarters (e.g., Sorenson and Stuart 2001). Because of the attribution of an investment to the headquarters, extraregional co-investment in these studies probably appears greater than it actually is.

Table 1

The Location of the Firms in This Study Compared with Previous Studies (Percentage)

Semiconductors	Kenney and Patton (2004) (N = 44)	Schoonhoven and Eisenhardt (1989) (All Startups, 1978–1986) (N = 107)
Northern California	61.4	70.4
Southern California	11.4	8.3
New York, New Jersey, Connecticut	6.8	3.7
	4.6 Massachusetts, Oregon, Colorado (tied)	3.7 Texas
		2.8 Colorado
Other	6.6	11.1

Telecommunications Equipment	Kenney and Patton (2004) (N = 53)
Northern California	41.5
Southern California	9.4
District of Columbia	9.4
Massachusetts	7.6
	5.7 Texas and Washington (tied)
Other	20.7

Biotechnology	Kenney and Patton (2004) (N = 65)	Stuart and Sorenson (2003) in 1995 (N = 1,278)	Kenney (1986, 134) in 1984 (N = 81)
Northern California	18.5	15.7	29.6
Massachusetts	16.9	12.6	12.3
New York, New Jersey, Connecticut	12.3	15.9	16.1
Southern California	7.7	12.2	13.6
	6.2 District of Columbia and Pennsylvania (tied)	7.6 District of Columbia	7.4 District of Columbia
Other	32.2	36	34

Note: The District of Columbia region includes Virginia and Maryland.
Source: Authors' compilation from the cited sources.

that filed SB-2 registration statements rather than S-1 statements. Also excluded were all firms that were created through buyouts, mergers, or other financial actions. In other words, the population consists only of de novo firms that were making their first IPOs. According to this criterion, the population included 44 semiconductor firms (SIC Code 3674), 53 telecommunications-equipment firms (SIC Codes 3661, 3663, 3669), and 65 biotechnology firms (SIC Codes 2833-2836). The entire database of 162 firms included 1,275 individuals.

One possible difficulty with our interindustry comparison is that the merchant semiconductor industry, which was established in the late 1950s, is much older than the biotechnology and telecommunications-equipment industries, which began in the late 1970s. The notion is that the semiconductor industry has had time to concentrate, whereas the two younger industries have not. This argument appears

flawed, since the biotechnology industry was more concentrated at its inception than it is today (see Table 1; see also Stuart and Sorenson 2003). Moreover, the semiconductor firms that were established after the mid-1980s are what is termed "fabless," which means that they do not manufacture their semiconductors; they only design and market them (O hUallachain 1997). Most frequently, the actual fabrication is done in Asia, usually in Taiwan (Leachman and Leachman 2004). In a sense, the fabless semiconductor industry can be considered a "new" industry.

Our study largely relied on the use of states as the regions. However, states, such as California, Texas, and Pennsylvania, include more than one economic region. In other cases, regions extend beyond the borders of single states. To control for this situation, we divided California into Northern and Southern California, although a case can be made for separating San Diego from the greater Los Angeles area. Because Texas and Pennsylvania did not have many firms, we decided to treat each of these states as a single region, although in the case of Texas, doing so may have overestimated the clustering, since both the Austin and Dallas–Fort Worth regions have firms that were in our database. In the case of Pennsylvania, nearly all the relevant activity is in the greater Philadelphia area. In terms of interstate clusters, we combined New Jersey and Connecticut with New York, and Maryland and Virginia with Washington, D.C. Our reason for this decision is that the entrepreneurial support networks are regional in orientation. For example, Maryann Feldman's (2001) study of the emergence of high-technology entrepreneurship in the Washington, D.C., area included Maryland and Virginia, although Feldman explicitly noted that technical activities may have a microregional spatial configuration.[3]

The geographic location of the constituents of the support network are portrayed graphically in a matrix format in tables in each industry section. In these tables, each entry represents a firm and a support-network actor or what we term a "dyad." Each table indicates the regional source of a network actor on the horizontal axis, and the regional target (the firm) served by this actor on the vertical axis. For example, in Table 2a, there are 27 dyads in which a Northern California semiconductor firm relied on the services of a Northern California law firm, two dyads in which a Southern California firm relied on the services of a Northern California law firm, and one dyad in which a firm in the New York region relied on the services of a Northern California law firm. In total, Northern California law firms served as the company counsel for 30 semiconductor IPOs. The cell Other-Other indicates the number of actors provided within state followed by a colon and the number provided out of state for regions not listed in the top six. For example, in semiconductors there were only three firms outside the top six regions; two of the three firms were served by law firms from New York, and the other was served by an out-of-state law firm.

With reference to venture capitalists, our data also differ from the data used by other scholars in that other researchers have typically used the VentureXpert database that presents all the investors in each startup by round. However, since we are interested in the *key* actors in the support network, our database includes only the venture capitalists on the board of directors. Because these venture capitalists are on the board of directors, they are responsible for monitoring the startup for the other venture capital investors and thus are the most intimately involved in the growth of the firm (Florida and Kenney 1988; Bygrave and Timmons 1992). Hence,

[3] Anecdotally, there is evidence for this microregional configuration in Silicon Valley, also. The biotechnology startups in the Bay Area are more highly concentrated north of Palo Alto and in the East Bay, while the semiconductor firms are concentrated in the Santa Clara area. Many of the nontechnology-based dot.coms were located in downtown San Francisco. Little attention has been given to microregional districts, although they are most likely what struck Marshall (1890) when he referred to industry mysteries of the trade as if they were in the air.

our data capture the most important venture capital relationships.

The Three Industries

The Semiconductor Industry

The geography of entrepreneurial networks in the merchant semiconductor industry is intimately related with the history of Silicon Valley. The preeminence of Silicon Valley as the location for new semiconductor startups can be traced to the formation of Fairchild Semiconductor in 1957 and the subsequent proliferation of spin-offs from it and its success. Hoefler (1971), an editor at *Electronic News*, was the first to comment on the proliferation of startups in Santa Clara County. In conjunction with this proliferation of "Fairchildren," an interpersonal network of information exchange emerged that was founded on common experience and overlapping acquaintances (Castilla, Hwang, Granovetter, and Granovetter 2000). Writing in 1978, Braun and MacDonald already appreciated the significance of local venture capitalists that understood the semiconductor industry. Indeed, a number of these venture capitalists originated in the semiconductor industry. The semiconductor industry in Silicon Valley is intimately related with the growth of venture capital in the region (for a history of the development of the venture capital industry in the Silicon Valley region, see Kenney and Florida 2000).

There has been some research on the clustering of semiconductor firms in Silicon Valley (Scott and Angel 1987), although it has not dealt directly with entrepreneurial support networks. Studies have shown that Silicon Valley has the largest concentration of semiconductor engineers and the greatest intraregional labor mobility in the country (Angel 1989; Almeida and Kogut 1999). Almeida and Kogut (1999, 912) found that the patent-citation behavior of semiconductor firms exhibited "strong localization effects and [that Silicon Valley] indeed [contributed] strongly to the overall [national] localization findings." Smaller, younger semiconductor firms, the ones that are in our population, were more strongly tied to local knowledge networks than were larger firms (Almeida and Kogut 1997). The findings of this research, which agreed with Saxenian's (1994) anecdotal research, concluded that labor mobility is critical for the transfer of knowledge in Silicon Valley, and, what is more important for our research, is the source of small startup firms and a method by which they can attract experienced employees to aid in the growth process. In other words, the knowledge and individuals that are the raw material for establishing a new semiconductor firm are densely concentrated in Silicon Valley.

Only a few studies have focused specifically on constituents of the support network for the semiconductor industry. For example, Schoonhoven, Eisenhardt, and Lyman (1990) found that new firms that were founded in Silicon Valley were able to introduce their initial product to the market more rapidly than were those that were established outside the region. Schoonhoven and Eisenhardt (1989) termed Silicon Valley an "incubator" region for semiconductor startups. Oddly enough, they found that in their sample, firms that received venture-capital investment and had outside board members were not significantly faster in introducing their first product. Yet after five years, firms that had moderate to high levels of venture capital invested were more likely to have higher sales than were those that did not—and it is exactly these firms that would be likely to undertake an IPO. Thus, the presence of venture capital had a significant positive effect on the long-term success of a firm.

In our database, semiconductor industry startups were remarkably concentrated, with 27 of the 44 being in Silicon Valley (see Table 1) and others being scattered in various regions.[4] Semiconductor firms

[4] The vast majority of the firms in our population are "fabless" semiconductor firms, which means that they contract out the production of their chips (Leachman and Leachman 2004).

exhibit the typical clustering suggested by the literature on Silicon Valley. Given this concentration and its persistence over time (see Table 1), one would expect that the support network would also be concentrated in the region.

The spatial characteristics of the firm and firm-lawyer dyad exhibit remarkable concentration (see Table 2a) along two dimensions: First, the startups and their law firms are highly concentrated in Silicon Valley and local law firms serve all the local startups. Second, Silicon Valley law firms serve 3 of the remaining 17 (18 percent) semiconductor startups outside Silicon Valley. This is an indicator of the strength of the specialized expertise related to semiconductors that has been developed by Silicon Valley law firms.

In terms of venture capital (see Table 2b), Northern California contains 34 dyads and both attracts venture capital from and supplies venture capital to other regions. What is most interesting is that only Silicon Valley startups had attracted foreign venture capitalists to their boards of directors (4 from Taiwan, 2 from Israel, and 1 each from France, Switzerland, and the United Kingdom).[5] Although the reasons for having foreign venture capitalists on a board of directors may differ in each case, this significant foreign representation on the board suggests that foreign venture capitalists have a great interest in funding Silicon Valley semiconductor firms. There is also evidence that these foreign venture capitalists participate in deals through ethnic (nationality) connections with the entrepreneurs (Kenney, Han, and Tanaka 2002; Dossani 2002). The Silicon Valley is the national center for semiconductor startups and thus attracts investment from venture capitalists both within and outside the region.

In terms of lead investment bankers (see Table 2c), in percentage terms, Silicon Valley is dominant and supplies investment banking services more widely than even legal services. This finding confirms what we know anecdotally, that investment banks have their semiconductor practices in the Bay Area (and usually in Silicon Valley). The widest dispersion was the board members who were not venture capitalists (see Table 2d). Silicon Valley firms appeared to have broad national networks because they appointed board members from around the nation, even though the region provided the greatest number of nonventure-capitalist board members to other regions.

The centrality of Silicon Valley in the semiconductor industry startups is remarkable. It is a concentrated location even while it attracts board members who are venture capitalists and nonventure capitalists from other locations, including overseas. Simultaneously, it also provided board members, both venture capital and nonventure capitalist, to the greatest number of locations. Perhaps, most significant was that it provided the most intimate service, legal services, to other regions. Finally, the Bay Area was a far more important location for investment bankers who were taking semiconductors firms public than was Wall Street. This finding indicates that not only is the semiconductor industry and its support network extremely concentrated in Silicon Valley, but the region acts as a hub, both attracting and providing services to other regions.

The Telecommunications-Equipment Industry

The inception of the startup economy in telecommunications equipment is difficult to date precisely. However, the first significant wave of startups that commercialized telecommunications equipment, which in reality was the networking of computers so they could share data, began in the early 1980s. Many of these early firms were commercializing pioneering research on computer networks done by the Xerox Palo Alto Research Center (PARC), and PARC was the source of a number of the

[5] Although these foreign firms indicate in their addresses that they are located overseas, they often have a small office in the Silicon Valley region that serves to monitor the investment (Kenney, Han, and Tanaka 2002).

Table 2

The Relationships Between Semiconductor Firms and Actors in the Support Network

a. Source of Lawyers

Target	Northern California	Southern California	Massachusetts	New York	Texas	Oregon	Other	Foreign	Total
Northern California	27	0	0	0	0	0	0		27
Southern California	2	3	0	0	0	0	0		5
Massachusetts	0	0	2	0	0	0	0		2
New York	1	0	0	2	0	0	0		3
Texas	0	0	0	0	2	0	0		2
Oregon	0	0	0	0	0	2	0		2
Other	0	0	0	2	0	0	0:1		3
Total	30	3	2	4	2	2	1		44

Note: 38 out of 44 actors on the diagonal (86.4 percent) are provided within the state.

b. Source of Venture Capitalists

Target	Northern California	Southern California	Massachusetts	New York	Texas	Oregon	Other	Foreign	Total
Northern California	34	0	1	3	0	0	1	9	48
Southern California	1	3	0	0	0	0	1	0	5
Massachusetts	2	0	3	0	0	0	1	0	6
New York	1	0	1	3	3	0	0	0	8
Texas	1	0	0	1	6	0	0	0	8
Oregon	1	0	1	0	0	0	0	0	2
Other	0	0	4	0	0	0	0:1	0	5
Total	40	3	10	7	9	0	4	9	82

Note: 49 out of 73 actors on the diagonal (67.1 percent) are provided within the state.

c. Source of Investment Bankers

Target	Northern California	Southern California	Massachusetts	New York	Texas	Oregon	Other	Foreign	Total
Northern California	26	1	0	0	0	0	0		27
Southern California	3	2	0	0	0	0	0		5
Massachusetts	0	0	2	0	0	0	0		2
New York	1	0	1	1	0	0	0		3
Texas	0	0	0	1	0	0	1		2
Oregon	1	1	0	0	0	0	0		2
Other	0	0	1	1	0	0	1:0		3
Total	31	4	4	3	0	0	2		44

Note: 32 out of 44 actors on the diagonal (72.7 percent) are provided within the state.

d. Source of Nonventure Capitalist Board Members

Target	Northern California	Southern California	Massachusetts	New York	Texas	Oregon	Other	Foreign	Total
Northern California	42	2	2	2	1	1	9	10	69
Southern California	5	6	1	0	0	0	0	0	12
Massachusetts	1	1	0	1	0	0	0	0	3
New York	3	0	1	2	0	0	2	2	10
Texas	0	0	0	1	1	0	0	0	2
Oregon	0	0	0	0	0	3	1	0	4
Other	1	0	0	2	0	0	2:3	0	8
Total	52	9	4	8	2	4	17	12	108

Note: 56 out of 96 actors on the diagonal (58 percent) are provided within the state.

early spinouts (Von Burg 2001; Chesbrough 2003). However, MIT and DEC in the Boston area were also leaders, and Boston had a number of startups. At that time, there were already the large incumbent telecommunications-equipment suppliers, such as AT&T's Western Electric (renamed Lucent), and the national equipment suppliers, such as Alcatel, Northern Telecom, Fujitsu, NEC, Ericsson, and Siemens, but they created few startups in the United States. The data-networking-equipment business was so small that it was of little commercial interest to the established firms (Von Burg 2001). The rapid rise of data traffic, first in the local area networks and then in wide area networks, such as the Internet, expanded rapidly, creating a market for specialized equipment for the transmission of data.

There have been few studies of the geography of the telecommunications-equipment startups. However, a genealogy of the most important pioneering computer-networking-equipment startups through 1989 shows that 15 were in Silicon Valley, 7 were in the Boston area, and 4 were scattered throughout the nation (Kenney and Von Burg 1999). The telecommunications-equipment industry evolved rapidly, with wave after wave of startups commercializing each new technical advance. The most significant of these startups would prove to be Cisco Systems (Mayer and Kenney 2004).

The vast majority of these firms were funded by venture capitalists, although a few of the early ones were bootstrapped (for the role of venture capitalists in funding telecommunications-equipment firms, see Von Burg and Kenney 2000). The telecommunications-equipment industry in both Silicon Valley and Boston was able to draw upon the existing entrepreneurial support network to fuel the new firm-formation process. However, in general, the Silicon Valley firms were established earlier and grew more quickly (Von Burg 2001), an advantage that, in network industries where standards are important, can lead to outsize gains (Arthur 1994). Firms, such as Cisco, Synoptics, 3Com, and Wellfleet, had extremely successful IPOs and, like Fairchild, soon became sources of new entrepreneurs. Although Silicon Valley and Boston were leaders in the 1980s, other regions that had significant human resources also spawned startups as the technology evolved. Other regions that had capable engineers included New Jersey, the home of Lucent's Bell Laboratories; Dallas, where a number of telecommunications-equipment manufacturers had located to serve MCI; and Washington, D.C. This industry was younger than semiconductors, and the expertise was more widely dispersed.

The Bay Area was home to 41.5 percent (22 of 53 firms) of the telecommunications firms in our study. However, there were firms in other regions, including Southern California; Washington, D.C.; Texas; and Massachusetts. As in other industries, law firms were concentrated in close proximity to their startup clients, with 45 out of 53 law firms being local, including those of all 9 of the startups outside the top six regions (see Table 3a). It is interesting that Southern California provided law firms for two Silicon Valley startups, while Silicon Valley provided law firms for three extraregional firms. In terms of venture capital, Northern California provided venture capital to other locations (see Table 3b). What is particularly interesting is the dominance of Northern California venture capitalists in funding Southern California startups. Although Northern California had only 41.5 percent of the startups, it provided 56 percent of the venture capitalists, who in effect served the entire country. However, as in the case of semiconductors, Silicon Valley also attracted more outside venture capitalists than did any other location. Although New York had few telecommunications-equipment startups, it provided venture capital services for regions that had little clustering. Foreign venture capitalists were less in evidence in telecommunications than in semiconductors, since there were only two investors from Taiwan in Northern California, one from Canada in Southern California, and one from France in Washington, D.C. As a result of other

Table 3

The Relationships Between Telecommunications-Equipment Firms and Actors in the Support Network

a. Source of Lawyers

Target	Northern California	Southern California	Massachusetts	New York	Texas	District of Columbia	Other	Foreign	Total
Northern California	20	2	0	0	0	0	0		22
Southern California	0	5	0	0	0	0	0		5
Massachusetts	0	0	4	0	0	0	0		4
New York	0	0	0	1	0	0	0		1
Texas	1	0	0	0	2	0	0		3
District of Columbia	0	0	0	0	0	4	1		5
Other	2	1	1	0	0	0	9:0		13
Total	23	8	5	1	2	4	10		53

Note: 45 out of 53 actors on the diagonal (84.9 percent) are provided within the state.

b. Source of Venture Capitalists

Target	Northern California	Southern California	Massachusetts	New York	Texas	District of Columbia	Other	Foreign	Total
Northern California	37	2	0	1	1	0	1	2	44
Southern California	6	0	0	2	0	0	0	1	9
Massachusetts	1	0	3	0	0	0	0	0	4
New York	0	0	0	1	0	0	0	0	1
Texas	1	2	0	0	1	0	0	0	4
District of Columbia	3	0	1	2	3	2	1	1	13
Other	8	0	1	7	0	2	3:4	0	25
Total	56	4	5	13	5	4	9	4	100

Note: 47 out of 96 actors on the diagonal (49.0 percent) are provided within the state.

c. Source of Investment Bankers

Target	Northern California	Southern California	Massachusetts	New York	Texas	District of Columbia	Other	Foreign	Total
Northern California	18	3	0	1	0	0	0		22
Southern California	1	4	0	0	0	0	0		5
Massachusetts	0	0	4	0	0	0	0		4
New York	0	0	0	1	0	0	0		1
Texas	1	0	0	0	2	0	0		3
District of Columbia	0	0	0	3	0	2	0		5
Other	3	1	3	1	0	2	1:2		13
Total	23	8	7	6	2	4	3		53

Note: 32 out of 53 actors on the diagonal (60.4 percent) are provided within the state.

d. Source of Nonventure Capitalist Board Members

Target	Northern California	Southern California	Massachusetts	New York	Texas	District of Columbia	Other	Foreign	Total
Northern California	29	5	0	2	2	2	10	6	56
Southern California	1	6	0	0	0	1	1	1	10
Massachusetts	0	0	6	1	0	1	0	0	8
New York	0	0	0	1	0	0	0	0	1
Texas	1	1	0	0	1	0	4	0	7
District of Columbia	1	0	0	1	0	4	4	0	10
Other	6	5	5	2	1	1	8:4	2	34
Total	38	17	11	7	4	9	31	9	126

Note: 55 out of 117 actors on the diagonal (47.0 percent) are provided within the state.

locations providing services, the startups were more widely distributed than were the venture capitalists who supported them. The investment bankers in Northern California were important, but largely handled deals within the region, while those in Southern California, Boston, and New York provided assistance to the firms in their region and, in some cases, to firms outside the region (Table 3c).

The supply of nonventure capitalist members of boards of directors was fascinating because Silicon Valley provided only 9 to firms outside the region, while its firms attracted 27 board members from outside the region, and was, by far, the most attractive region for board members who were nonventure capitalists (see Table 3d). This is probably the result of Silicon Valley startups forming extraregional strategic alliances with established telecommunications-equipment firms from outside the region (Soh and Roberts 2003) through which the extraregional firms also obtained board memberships. Southern California actually provided more nonventure capital board members to firms outside its region than did Northern California. Boston, New York, and Washington, D.C., also provided some board members extraregionally, although in each case, the number was either 5 or 6, and thus only about half of the members were provided by either of the two California regions.

In this industry, 84.9 percent of the lawyers were from the same region as the startup. This proportion dropped significantly in the case of the venture capitalists and nonventure capitalist board members, only 49 percent and 47 percent of whom, respectively, were in the same region as the firm. Investment bankers were more regionally proximate, since 60.4 percent were from within the region. Clearly, the telecommunications-equipment industry is concentrated in Silicon Valley; however, a few other regions have noticeable concentrations of firms and some constituents of the entrepreneurial support network.

The Biotechnology Industry

The biotechnology industry was established on the basis of university science (Kenney 1986), and university research continues to discover new biotechnology inventions that may have the potential for commercial exploitation. It is interesting that when it comes to studying high-technology clustering, it is biotechnology that has received and continues to receive the greatest attention (Cooke 2002; Orsenigo 1989; Prevezer 1997). Biotechnology contrasts with the other two industries because "star" university scientists were essential in the early days of the industry's development. The location of the universities that employed these star scientists was a determining factor in the location of the early startups (Zucker, Darby, and Brewer 1998; Zucker, Darby, and Torero 2002).[6] Key scientists served on scientific advisory boards and even the firms' boards of directors (Kenney 1986; Krimsky 2003). A firm's founders or the chair of a firm's scientific advisory board were much more likely to be located in close proximity to the firm than were other members of the advisory board (Audretsch and Stephan 1996). In other words, proximity to universities (and academic research institutes) was central to the formation of the early biotechnology startups and continues to be influential.

With the exception of the spatial coordinates of venture capital investors, the geography of support networks in biotechnology has received little attention. A number of studies have shown that the presence of local venture capital has an important positive impact on the formation of new firms (Zucker, Darby, and Brewer 1998; Stuart and Sorenson 2003). However, Stuart and Sorenson (2003) found that as the biotechnology industry matured, proximity

[6] There is little evidence that the location of the pharmaceutical industry, whose largest cluster is in the New Jersey–New York City area, was a significant driver of the industrial clustering (see, e.g., Zucker, Darby, and Brewer 1998; Stuart and Sorenson 2003; Romanelli and Feldman 2004).

to factors, such as universities, incumbent firms, and venture capital, declined in importance (for a discussion of regions and biotechnology, see Cooke 2001). This finding is interpreted to mean that the basic knowledge that is necessary to establish a biotechnology firm has become more generalized. An alternative explanation that is as plausible and is not mutually exclusive is that the capability and desire to start firms on the basis of university knowledge have become more widely diffused and are facilitated by the ability to gain access to distant actors in the entrepreneurial support network.

The biotechnology firms are more widely dispersed than are firms in the other two industries. One possible explanation is that biotechnology includes a greater variety of firms than do the other two industries. This may be true, but nearly all the firms in our population were in the human therapeutics and diagnostics field, thereby suggesting that we were examining a set of firms that should be more *concentrated* geographically. However, our population is, as Table 1 shows, roughly comparable to that of Stuart and Sorenson (2003), which contained the total population of biotechnology startups.[7]

That the two largest concentrations in our study are in Northern California and Boston has been confirmed by all extant research and is not surprising, considering the concentration of first-rank research institutions in both locations. Recent research has added San Diego to these two large regions (Powell, Koput, Bowie, and Smith-Doerr 2002; Romanelli and Feldman 2004; Gertler and Levitte 2003; Cooke 2003). Romanelli and Feldman (2004) also found that in human therapeutics, these three regions were the most dynamic in terms of the spinouts of firms from existing firms and in attracting firms from other locations; nevertheless, in historical terms, there has been little further spatial concentration of the industry.

The most comprehensive and detailed study of the spatial dimensions of the relationship between biotechnology firms and venture capitalists was by Powell, Koput, Bowie, and Smith-Doerr (2002), who found that the spatial patterns of funding have changed from 1988, when there was a simple pattern of funding in which New York venture capitalists funded firms locally, in Boston, and in the rest of the country, while the Bay Area funded firms locally, in San Diego, and in the rest of the country. In 1999, the spatial pattern of venture capital investing became more complicated as regional venture capitalists began funding local firms and venture capitalists in the established centers disbursed their funds more widely. In keeping with Sorenson and Stuart (2001), Powel, Koput, Bowie, and Smith-Doerr found that for the biotechnology firm, local venture capital funding creates a "reputation" effect that attracts venture capital to the firm from outside the region.

In this industry, 67.7 percent of the lawyers are located in the same region as their clients, with Boston and New York providing the greatest number of lawyers to extraregional clients (see Table 4a), and Northern California being largely self-sufficient. In terms of the geography of venture investing in biotechnology, our results are similar to those of Powell, Koput, Bowie, and Smith-Doerr (2002). Overall, in only 24.8 percent of all the cases did venture capitalists invest in local firms. Northern California venture capitalists served twice as many extraregional firms as firms in the region, even while Northern California received inward investment from approximately 1.5 times as many venture capitalists as it provided internally (Table 4b). Boston had a similar pattern. What was most remarkable was that New York, which served only 2 local startups, provided venture capital to other locations in 35 cases. Put differently, New York was 17.5 times more likely to provide venture capital outside its region as inside it. In addition, there was also less

[7] It is possible that there are biotechnology subsectors that cluster more tightly, but this is likely because the subsector, such as agriculture, has few startups.

Table 4

The Relationships Between Biotechnology Firms and Actors in the Support Network

a. Source of Lawyers

Target	Northern California	Southern California	Massachusetts	New York	Pennsylvania	District of Columbia	Other	Foreign	Total
Northern California	10	0	0	0	0	0	2		12
Southern California	2	2	1	0	0	0	0		5
Massachusetts	0	0	9	2	0	0	0		11
New York	0	0	3	5	0	0	0		8
Pennsylvania	0	0	0	0	4	0	0		4
District of Columbia	0	0	0	1	0	3	0		4
Other	1	3	1	2	1	1	11:1		21
Total	13	5	14	10	5	4	14		65

Note: 44 out of 65 actors on the diagonal (67.7 percent) are provided within the state.

b. Source of Venture Capitalists

Target	Northern California	Southern California	Massachusetts	New York	Pennsylvania	District of Columbia	Other	Foreign	Total
Northern California	8	0	3	6	0	0	2	0	19
Southern California	2	1	1	3	0	0	0	0	7
Massachusetts	3	1	8	10	0	0	1	1	24
New York	0	0	3	2	0	0	0	0	5
Pennsylvania	1	0	0	6	2	0	3	1	13
District of Columbia	0	0	0	1	1	2	1	0	5
Other	10	2	7	9	1	0	3:2	1	35
Total	24	4	22	37	4	2	12	3	108

Note: 26 out of 105 actors on the diagonal (24.8 percent) are provided within the state.

c. Source of Investment Bankers

Target	Northern California	Southern California	Massachusetts	New York	Pennsylvania	District of Columbia	Other	Foreign	Total
Northern California	6	3	0	2	0	0	1		12
Southern California	3	1	1	0	0	0	0		5
Massachusetts	0	0	6	4	0	0	1		11
New York	0	1	1	6	0	0	0		8
Pennsylvania	0	0	0	4	0	0	0		4
District of Columbia	0	0	1	3	0	0	0		4
Other	1	0	2	14	0	1	0:3		21
Total	10	5	11	33	0	1	5		65

Note: 19 out of 65 actors on the diagonal (29.2 percent) are provided within the state.

d. Source of Nonventure Capitalist Board Members

Target	Northern California	Southern California	Massachusetts	New York	Pennsylvania	District of Columbia	Other	Foreign	Total
Northern California	12	4	4	5	0	2	8	4	39
Southern California	2	8	1	3	1	1	0	0	16
Massachusetts	0	2	11	8	0	0	4	0	25
New York	2	3	1	13	1	0	1	2	23
Pennsylvania	1	0	0	5	5	0	2	0	13
District of Columbia	0	1	0	3	0	5	0	3	12
Other	5	4	6	8	1	6	15:11	10	66
Total	22	22	23	45	8	14	41	19	194

Note: 69 out of 175 actors on the diagonal (39.4 percent) are provided within the state.

investment by foreign venture capitalists in New York, since there were only three such investments. In sum, in biotechnology, venture capital was far less local, and New York was the national center for the provision of venture capital for biotechnology firms, even though California and Boston venture capitalists were also significant extraregional investors. In the case of biotechnology, the important regional centers of venture capital invested nationally, and intraregional investing was less important than was extraregional investing.

Investment banking was significantly less complicated in that New York was clearly dominant, providing 50.8 percent of all the investment bankers for the industry (see Table 4c). Boston and Silicon Valley together provided 32.3 percent of the other investment banking services, largely on the basis of providing services to local firms. As a result, the local provision of investment banking services was only 29.2 percent of the entire population. In biotechnology, New York was an important source of service for both venture capital and investment banking, even though it did not have a large concentration of biotechnology firms. There was only minimal clustering between the financial intermediaries and the firms.

The pattern for nonventure capitalist board members was complicated (see Table 4d). As was the case for venture capitalists and investment bankers, the New York area boasted the largest number of nonventure capitalist board members in every other region. Silicon Valley was the largest attractor of outside nonventure capitalist board members, attracting proportionally more than either Massachusetts or New York. Moreover, the biotechnology industry was the only one in which the "other" category in both the provision and attraction of nonventure capitalist board members was so large. This finding illustrates how widely dispersed the relevant knowledge for biotechnology is and how the support networks are far more national than in the other two industries. It suggests that biotechnology is not especially clustered as far as high-technology industries are concerned. In the next section, we discuss whether there are significant differences in the clustering of the support networks for these three industries.

Interindustry Comparison

In our discussion of the three industries, we described the history of the industries and examined the geography of the entrepreneurial support networks in each industry. We showed that in terms of location, the semiconductor industry was the most concentrated and the biotechnology industry was the least concentrated, with telecommunications equipment being in between. This section examines the proximity of the firms to their support network.

Before we discuss the results, it is important to note that there are differences between the biotechnology and electronics industries along three dimensions. First, in biotechnology (pharmaceuticals), patenting is of greater importance than in electronics (Cohen and Walsh 2002; Merges and Nelson 1990; Lim 2004). Second, the development, testing, and introduction of a new drug into the marketplace is a far longer process than is usual for the introduction of a new electronics technology product. Third, strategic partnerships with existing firms are critical in the early days of a biotechnology firm (Kenney 1986; Powell, White, Koput, and Owen-Smith forthcoming) because the costs of developing, testing, and introducing a new drug are usually so much greater than they are for an electronics product.

To compare the spatial distribution of the actors across industries, we separated each dyad into those in which the members were within 50 miles of each other and those in which they were more than 50 miles apart.[8] Table 5 shows the distribution of these dyads

[8] All these distances are from physical address to physical address with the following exceptions: First, we used the proxy for the location of the investment banker—the investment banker's lawyer's address. Second, in 19 domestic cases, we were unable to establish exactly a person's address, but we were able to locate in which

Table 5

Proximity of Constituents in the Support Network to Firms

	Semiconductors		Telecommunications		Biotechnology	
	Number	Percent	Number	Percent	Number	Percent
Lawyers						
50 miles or less	35	79.5	40	75.5	44	67.7
Over 50 miles	9	20.5	13	24.5	21	32.3
Venture Capitalists						
50 miles or less	45	54.9	44	44.0	28	25.9
Over 50 miles	37	45.1	56	56.0	80	74.1
Investment Bankers						
50 miles or less	31	70.5	26	49.1	17	26.2
Over 50 miles	13	29.5	27	50.9	48	73.8
Nonventure Capitalists						
50 miles or less	55	50.9	50	39.7	66	34.0
Over 50 miles	53	49.1	76	60.3	128	66.0

for the four support-network constituents across these three industries. There were two reasons for selecting 50 miles as a dividing point. First, as one can see from the histogram in Figure 1, which plots the distances between dyads for all the members of the entrepreneurial support network, 50 miles was a plausible separation point for distances.[9] Almost half the members of a support network (48.9 percent) are within 50 miles of their firms. Beyond 50 miles, the distribution was mildly bimodal, with a slight concentration from 100 to 450 miles and another concentration from 2,400 miles and beyond. All foreign-based board members were considered to be over 50 miles away from their firms. The second reason for choosing 50 miles is that, subjectively, distances of less than 50 miles, or an hour's driving time, can be considered close, while distances of more than 50 miles can be considered to be far away.

After we separated the dyads into greater than or less than 50 miles apart, we then conducted a chi-square analysis to determine whether these firms came from underlying different populations. The results indicate whether the industries differ statistically from each other in the proximity of their respective support networks.

Before we discuss the results of the chi-square analysis, it is valuable to review some of the similarities and differences in the industries. First, the semiconductor industry was overwhelmingly located in Silicon Valley (61.4 percent) and was concentrated overall, with 93.2 percent of all the firms found in just six regions. Telecommunications equipment was also concentrated in Silicon Valley (41.5 percent), with 75.5 percent in six regions. Biotechnology differed markedly from the other two industries in that, although Silicon Valley was the leading region, it contained only 18.5 percent of the firms, and the top six regions encompassed only 67.7 percent of all the firms. Thus, no single region was dominant in biotechnology, whereas in the other two industries, Northern California was dominant.

Law Firms

The results of our chi-square analysis indicate that there is no statistical difference

city or county the person resided and could therefore determine if the person was more than or less than 50 miles from his or her firm. In addition, all foreign actors were assumed to be over 50 miles away. Only 71 actors out of a total of 1,113 (6 percent) could not be located at all.

[9] We did not use the metropolitan commute boundary because the venture capitalist does not actually commute but, rather, visits frequently or, at least, once a month.

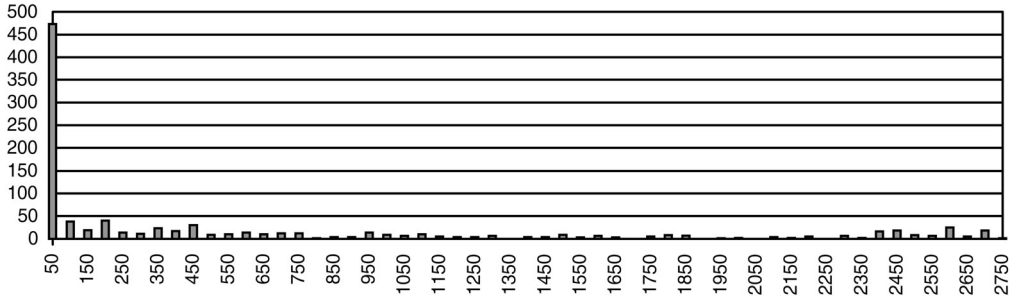

Figure 1. Histogram of the distances in miles between each dyad in each industry.

between the three industries in the case of the location of the startup and the startup's law firm (see Table 6).[10] The provision of legal services was spatially close to the entrepreneurial firm and is the most highly localized component of the support network. This finding is not surprising because of the intimate relationship between the law firm and the startup. Suchman (2000) found that Silicon Valley law firms were intimately involved in the affairs of their clients, playing the role of "counselors" in the early life of the firm and assisting in a variety of ways, such as providing introductions to venture capitalists. This intimacy argues against long-distance relationships. However, 21.6 percent of the startups retained law firms from outside their region. In this case, the major regions provided services to peripheral startups. A plausible explanation for this finding is that the startup may not have been able to find the necessary expertise locally and thus obtained the expertise from a major center. Although not statistically significant, the use of extraregional law firms was the greatest in biotechnology, which is also the industry with the greatest dispersion.

[10] When these industries were compared as a group, in addition to being compared pairwise, the same chi-square result was found. That is, the proximity of law firms, as measured by the frequency with which they are less than or more than 50 miles away from their client firm, is statistically indistinguishable across these industries.

Venture Capitalist Board Members

In the case of venture capitalists, previous research led us to expect that there would be a significant level of co-location for the venture capital firms (Florida and Kenney 1988; Sorenson and Stuart 2001; Gompers and Lerner 1999). Silicon Valley is important as a national center of venture capital because it receives approximately 30 percent of all venture capital investments. This is particularly true for the semiconductor and communications firms, whereas in biotechnology, Silicon Valley plays a secondary role to East Coast venture capital. In this case, though the venture capitalists supporting semiconductors were more concentrated than those supporting telecommunications equipment, there was no significant difference in proximity (see Table 6). The semiconductor startups also relied far more heavily on foreign venture capitalists than did any other industry. In semiconductors, 11 percent of the venture capitalists were foreign, compared to only 4.0 percent and 2.8 percent, respectively, in telecommunications equipment and biotechnology. Despite this foreign involvement, in both semiconductors and telecommunications equipment, the venture capitalists were significantly closer to the firms than was the case in biotechnology (see Table 6). These results suggest that the venture capital portion of the support network is significantly more extraregional for biotechnology than for the two electronics-based industries. One reason for this finding may be that during the past

Table 6

Chi-Square Analysis of Differences Among Actors Across Industries

	Semiconductors versus Telecommunications		Telecommunications versus Biotechnology		Semiconductors versus Biotechnology	
Actors	Chi-square Value	Significance	Chi-square Value	Significance	Chi-square Value	Significance
Lawyers	0.22751	N.S.	0.8614	N.S.	1.84804	N.S.
Venture Capitalists	2.13361	N.S.	7.49424	.01	16.50211	.001
Investment Bankers	4.54264	.05	6.61173	.05	20.84674	.001
Nonventure Capitalists	2.97184	.1	1.05965	N.S.	8.25676	.01

Note: The 2x2 contingency table comparison of the proximity of lawyers for semiconductor and telecommunications firms yields a chi-square of 0.22751, which is insignificant at 1 degree of freedom. This finding seems plausible from an examination of Table 5, which indicates that 79.5 percent of the lawyers for semiconductor firms are within 50 miles of the firms, compared to 75.5 percent of the lawyers for telecommunications firms. These proportions are quite similar. Significantly high chi-square values that result from comparing semiconductor and biotechnology venture capitalists, for example, indicate that these proportions are significantly different statistically.

decade, a group of venture capitalists specializing in the life sciences emerged. Given the dispersal of the biotechnology startups, it is likely that few venture capitalists could survive on biotechnology deals from their region alone; therefore, there was much extraregional investing. It is also true that a number of venture capital firms have partners that specialize in biotechnology. Firms outside Northern California, Massachusetts, and New York relied on these regions for venture capital services, since they provided over half the venture capitalist board members.[11]

Up to this point, we have examined the individual venture capitalists who sit on the boards of these firms. One may ask if these same patterns of proximity would hold if we shifted our attention to the individual firms themselves. Sorenson and Stuart (2001) observed that venture capital firms are more likely to fund a spatially distant firm if another venture capitalist whom they have had experience with is involved with the firm and if that firm is geographically close. We may expect such reliance by distant venture capitalists on a geographically close venture capitalist board member to monitor and advise the firm. To determine if this was true, we restricted our attention to firms that had at least one venture capitalist on their boards of directors and then looked at the proportion of these firms that had at least one venture capitalist board member who was located within 50 miles of the firms.[12] We found that 73.0 percent of such semiconductor firms, 57.5 percent of such telecommunication firms, and 44.4 percent of such biotechnology firms had at least one venture capitalist board member within 50 miles. This finding suggests that especially in the case of biotechnology, it was not necessary to have even one venture capitalist within 50 miles of the firm. A chi-

[11] Northern California, Massachusetts, and New York together provided 45.0 percent, 61.1 percent, and 66.7 percent, respectively, of all venture capitalist board members for semiconductor, communications, and biotechnology firms outside these three areas. In comparison, the percentages for nonventure capitalist board members were 38.5 percent, 27.9 percent, and 37.8 percent.

[12] For example, 84.1 percent of semiconductor firms, 75.5 percent of telecommunication firms, and 69.2 percent of biotechnology firms had at least one venture capitalist on their boards of directors.

square analysis indicated that the differences between semiconductors and telecommunications and between telecommunications and biotechnology were not significant, whereas the difference between semiconductors and biotechnology was significant at the .01 level.

Investment Bankers

In investment banking, the support network was the most highly concentrated in semiconductors, less concentrated in telecommunications equipment, and the least concentrated in biotechnology—and the difference was significant in each case (see Table 6). In semiconductors and, to a substantial degree, in telecommunications equipment, Silicon Valley was self-supporting and even provided investment banking services to other regions. This finding is not remarkable because in these two industries, Silicon Valley remains the overwhelming national center. Therefore, investment banks have been attracted to the region as a source of public offerings. That the investment bankers who handled IPOs were even more concentrated than were the startups suggests that the investment banking function could be and often was provided remotely in telecommunications equipment and particularly in biotechnology. Silicon Valley is significant because, over time, it has built such a strong electronics base that the investment banks, such as Goldman Sachs, Morgan Stanley, and J. P. Morgan, located their electronics-based practices in the region. For semiconductors, Silicon Valley provided investment banking services not only for local firms, but also for extraregional startups. To a lesser degree, this was also the case in telecommunications equipment. In biotechnology, however, the pattern of Silicon Valley discharging its own investment banking functions does not hold; although it undertakes some investment banking activities in biotechnology, it is by no means self-sufficient. In fact, New York appears far more important in investment banking. One hypothesis would be that since the biotechnology knowledge base is far more dispersed (Zucker, Darby, and Torero 2002; Stuart and Sorenson 2003), there is no overwhelming region to attract the premier U.S. investment banks. For this reason, these banks would more likely be located in the investment banking cluster, New York.

Nonventure Capitalist Board Members

In semiconductors and telecommunications equipment, the nonventure capitalist board members were more dispersed than was any other constituent of the entrepreneurial support network, in large measure because of the large number of extraregional board members serving Silicon Valley firms. In contrast, in biotechnology, the nonventure capitalist board members were more likely to be in the region of the firms they served than were the venture capitalist board members and the investment bankers. Despite this wider relative dispersion of nonventure capitalist board members in the two electronic industries, these board members were still located more closely to their client firms than was the case in biotechnology. Among the top six regions, 68.3 percent of semiconductor, 54.7 percent of telecommunications, and 40.3 percent of biotechnology nonventure capitalist board members were provided locally. One possible explanation for the large number of extraregional board members is that Northern California startups are the most sophisticated and thus understand how to make their firms attractive to potential purchasers of their stock, by capturing the "reputation" benefits of a strong board of directors, regardless of their location (Beatty and Ritter 1986; Megginson and Weiss 1991; Baker and Gompers 2003).

In comparing the proximity of the directors, we would have hypothesized that the venture capitalist board members would be more likely to be close to the firms than

would the nonventure capitalist board members. However, this was not the case.[13] Both types of board members shared similar patterns of proximity to the firms. In other words, in semiconductors, there was no significant difference between the board members because they were close, while in biotechnology, there was no significant difference because they were not close. This finding further highlights the differences in the entrepreneurial support networks in biotechnology and the electronics-based industries.

The concentration of the support network for electronics in Northern California is striking and undoubtedly is a case of the coevolution of the industry and support network (Kenney and Patton 2004). The attraction of venture capitalist board members from around the world and nonventure capitalist board members from other locations to Northern California suggests that the region has developed a mechanism for overcoming what may have evolved into a weakness, namely, too great insularity. It could also be an outcome of the fact that entrepreneurs are attracted to Silicon Valley from all parts of the globe and may be drawing upon networks in their regions of origin (Dossani 2002).

If the electronics-based industries are concentrated, then biotechnology is comparatively dispersed. Previous research suggested that this is the case because of the dependence of the industry upon university research that continues to be dispersed. As a result, the path-dependent clustering that Arthur (1994) found or the geographic concentration process that Storper and Walker (1989) suggested do not operate as strongly in this industry and likely will not operate as long as universities continue to generate commercializable science. The ability to establish startups in regions without important components of the support network is facilitated by the willingness of actors in the entrepreneurial support networks to work with distant firms. As a corollary, this ability permits the concentration of support network members in the financial field in New York City. It also suggests that in the case of biotechnology, too much emphasis may have been placed on the significance of proximity.

[13] With regard to the proximity of venture capitalist and nonventure capitalist board members, the chi-square analysis indicated that there is no significant difference between these two types of board members' proximity in each industry.

Discussion and Conclusion

The findings of this study strongly suggest that conclusions about the spatial configuration of networks that are drawn from a single industry may be misleading. Comparative research provides an antidote to generalizations from studies of individual industries. Furthermore, our comparison benefited from being conducted at the same time in the life cycle of all the firms. Although biotechnology exhibits considerable clustering of both firms and support networks, our findings led us to question whether there are really global-class biotechnology clusters. In fact, we are tempted to go even further and question whether biotechnology actually has "clusters"; rather, the concentrations may be better referred to as concentrations, thereby not overemphasizing the interfirm relational aspects. Zeller (2004) provided some suggestive evidence for our conclusion in his finding that Swiss pharmaceutical firms that intend to participate in the U.S. biotechnology industry actually are able to choose to locate their R&D operations in the San Francisco Bay Area, Boston, or San Diego. In contrast, a multinational that is seeking to participate in the semiconductor or telecommunications equipment industries has little choice but to locate in the Bay Area. Moreover, a European venture capitalist or investment banker who wanted to locate a biotechnology-oriented investment operation in the United States would have at least four choices: San Diego, San Francisco, Boston, or New York. Here again, the choice would be much simpler in the other two industries.

Clustering in biotechnology (and, perhaps, in other industries, such as medical devices) may be inhibited because the source of entrepreneurs in this industry is not as concentrated in existing firms, but rather is dependent upon universities. Also, it is possible to speculate that biotechnology firms may not be as dependent upon each other and on suppliers, thus limiting the centripetal forces that may draw them together. Thus, the normal cluster effects may not be sufficient to create the winner-take-all regional dynamics that scholars have predicted. If the centripetal forces are not as strong for the firms and the sources of knowledge are more dispersed, then it is not surprising that the constituents of the entrepreneurial support networks are not as concentrated in close proximity to the firms. Oddly enough, this possibility suggests that the literature on biotechnology clustering is, in some way, missing the point that clusters in biotechnology are far less significant than are those in some other high-technology industries.

Turning to the actors in an entrepreneurial support network, we found that the venture capitalists and investment bankers are concentrated in three regions: New York, Boston, and Silicon Valley. The persistence of these concentrations provides some explanation of the patterns of proximity that we observed between firms that have gone public and these network members. Startups in industries whose clusters are coincident with these three regions enjoy close proximity to resources, as is the case of semiconductors in Silicon Valley. However, the concentration of venture capitalists and investment bankers in New York does not appear to have had a significant impact on the establishment of successful startups there. This finding highlights the notion that entrepreneurship may be the primordial requirement (Feldman 2001). While telecommunications assumes something of an intermediate case between semiconductors and biotechnology, biotechnology is characterized by an economic geography that is quite different from that of semiconductors.

Because biotechnology startups are more dispersed outside the venture capital and investment banking concentrations, biotechnology startups rely more on these services being provided extraregionally. The co-location of venture capital and biotechnology startups has been well documented, but only when biotechnology is compared to other industries does it become clear that the hypothesized close proximity to venture capital and other entrepreneurial support is relative.

The actor in the entrepreneurial support network who was the most likely to maintain close proximity across all three of these industries was the startup firm's lawyer. This finding suggests the centrality of the law firm in the local support network and that those who are interested in encouraging technology-based entrepreneurship may have underestimated the significance of law firms in the firm-formation process. Economic development professionals may consider how they could mobilize local law firms to support the entrepreneurial process, since it seems that lawyers are the support network actors who are the most localized.

For policy makers, our results are important. They indicate that it may be far easier to encourage the establishment of a number of biotechnology firms than it would be to encourage semiconductor or telecommunications equipment firms, but that a cluster effect that includes the emergence of a support network may not occur in biotechnology—a finding that is in agreement with Romanelli and Feldman's (2004) findings that many biotechnology clusters do not give rise to a powerful spinoff phenomenon. The difficulty of other regions to enter existing electronics industries is demonstrated by both the concentration of the assets of the support network and the location of the human resources (Almeida and Kogut 1997; Angel 1989). The assets in these electronics-based industries are so concentrated that developing clusters in other regions could be difficult because the location has become fixed (Harvey 1982). Because universities are not as significant in the semiconductor industry (Moore and

Davis 2001), unless there is another source of skilled personnel who are able to establish new firms, there may be little opportunity to initiate a virtuous cycle of successful firms, IPOs, spin-offs, and yet more successes that facilitate the creation of strong local entrepreneurial support networks. The source of the entrepreneurs appears to have a great influence on the clustering and dynamics of support networks.

This finding suggests that two economic development strategies may be possible. First, improving the local university's biomedical capabilities may be more successful as an economic development policy than trying to develop an electronics cluster. Second, it should be possible to do so without having to co-localize all or even most of the actors in the support networks, since they are available from outside the region. Further research should be able to answer whether a similar situation holds in other biomedical fields, such as biomedical instruments. However, it also suggests that any biotechnology cluster that is developed will not be powerful as an economic development tool because there is little likelihood that it will become truly dominant. This is the case even for the two regions that one may have expected to develop dominance, Boston and Silicon Valley, neither of which actively attempted to develop a biotechnology cluster. Entry may be relatively easy, but dominance will likely be unachievable.

The economic geography of entrepreneurship and support networks for entrepreneurship is a fertile area of research for economic geography. Unfortunately, the preponderance of research in this area is being conducted outside economic geography. Our study has demonstrated the ways in which empirical data on spatial location can be used to gain a better understanding of the locational dimensions of organizations that provide services to startups. It should be viewed as an early contribution to what we believe is an important effort to test and improve theories on the spatial determinants of entrepreneurship.

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