Title

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ABSTRACT

Using a unique database derived from U.S. initial public stock offering prospecti, the authors 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 start-up 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. Our results suggest that generalization about the economic geography of high-technology industries drawn from a single industry study can be misleading. We find that biotechnology has a far more dispersed network structure than the two electronics-related industries. We suggest that the case of biotechnology suggests 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 and economists. Also, we argue that contrary to common belief biotechnology and its support network does not exhibit as great clustering as does either semiconductors or telecommunications equipment. Suggesting that for economic development planners, it may be easy to encourage biotechnology start-ups, but the synergies from the industry may not be as powerful as in other high-technology fields.

In the last two decades, the quest to better understand the spatial dimensions of innovation and entrepreneurship has attracted not only geographers, but also economists, sociologists, and business school researchers.[1] Motivated by Alfred Marshall's (1890) observation that related economic activities are often concentrated within certain locales that have been variously termed clusters or industrial districts, scholars now agree that spatially localized, economically significant synergies of various sorts exist (Porter 1998; Storper and Walker 1989). Further, the literature has come to recognize that regional concentrations of economic activity can encourage entrepreneurship and innovation.

Studies of clusters explicitly recognize horizontal clustering, i.e., between competing firms, and vertical clustering, i.e., separate segments of the value chain (for example, a supplier and assembler).[2] With the exception of venture capitalists, less attention has been given to the actors in entrepreneurial clusters that assist entrepreneurs in creating a new firm. In this paper, we term these actors as constituents of an "entrepreneurial support network." Remarkably, though the extant literature clearly notes the importance of local business services (Porter 1998; Bennett et al. 1999; Mueller and Zenker 2001; Scott 2002), there have been fewer empirical studies of the location of business services supporting entrepreneurship. The common belief is that these services are highly clustered in close proximity to the start-up. This paper explores this assumption by examining four constituents of the support network: law firms, venture capitalists on the firm's board of directors, investment bankers, and independent members of the firm's board of directors in three different industries: semiconductors, telecommunications equipment, and biotechnology.

The importance of these entrepreneurial support networks has long been recognized and been variously termed a "social structure of innovation" (Florida and Kenney 1988), an "ecosystem" (Bahrami and Evans 2000), "incubator region" (Schoonhoven et al. 1990), or "habitat" (Moon et al. 2000) no reference for Moon et. al.. For a variety of reasons, most empirical studies of these networks have concentrated on individual constituents of the network such as venture capital (Bygrave and Timmons 1992; Florida and Kenney 1988; Sorenson and Stuart 2001, among others) 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 start-up's network. The location of other constituents of the support network including investment bankers, accountants, or persons capable of serving on the board of directors has received far less attention.

Previous research has invariably focused on only one constituent of the entrepreneurial support network or has examined the constituent with insufficient attention to the actual industries within which

[1] For a comprehensive review and synthesis of thinking about entrepreneurship in the social sciences, see Thornton (1999).
[2] In economic geography, see classic texts such as Storper and Walker (1989) or even earlier, Perroux (1988).

the start-up operates. This is despite the fact that it is widely recognized that other characteristics of high-technology industries such as semiconductors and biotechnology differ significantly (Cohen and Walsh 2002; Lim 2003; Swann and Prezever 1996). The high-technology industry that has received the most attention concerning its spatial configuration is biotechnology (Powell et al. 2002; Zucker et al. 2002), though Zook (2002) examined the regional distribution of venture capital and Internet start-ups. This paper 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 their initial public stock offering.

This paper examines 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 start-up? If there are differences, can hypotheses be advanced that might explain these differences?

The start-ups in these three industries exhibit similar outward characteristics, namely they are innovation driven, entrepreneurship is a significant path for the commercialization of innovations, start-ups can attract significant sums of venture capital, the start-ups aim to grow rapidly, and they are structured to achieve significant capital gains by having a liquidity event either in the form of being acquired or offering stock to the public.

The four different actors in these industries create a complicated structure for the paper. To simplify this structure, each industry is examined separately and then the interindustry comparisons are discussed in a separate section. We begin by reviewing the general literature on entrepreneurial clusters and entrepreneurial support networks. Studies related specifically to a single industry are discussed in the industry sections. The second section describes the four constituents of the support network that are studied in the paper. The third section describes the database, and discusses its strengths and weaknesses. This is followed by the three industry sections 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 upon how this study contributes to the literature on high-technology clustering, and what it suggests about entrepreneurial support networks.

Previous Research

The regional clustering of economic activity and the entrepreneurship involved in new firm formation is widely recognized as a socially embedded activity.[3] In regions having a high incidence of new firm formation, various institutions have arisen to meet the demands of such entrepreneurs. The interplay of entrepreneurs launching firms, and the establishment of networks of institutions dedicated to assisting such start-ups, has helped produce regions characterized by the rapid development of innovations, frequently introduced by new firms.

In more general terms, the tendency of different types of economic activity to concentrate geographically is a widely observed phenomenon over time and across countries. The economist Alfred Marshall in 1890 was the first to comment extensively on the nature and importance of industrial clustering for economic growth and innovation. In recent years, his original observations have been extended by Michael Piore and Charles Sabel (1984), by contemporary geographers Malecki (1980) and Storper (1995), and placed at the center of a newly revived economic geography (Krugman 1991).

Silicon Valley is often considered the ideal-typical innovative region, and many have credited the networks of organizations and individuals dedicated to assisting start-ups as being an important factor in the region's innovative vitality (Bahrami and Evans 2000; Castilla et al. 2000; Cohen and Fields 2000; Kenney and von Burg 1999; Saxenian 1994). Such concentrations of activity are most frequently referred to as clusters or industrial districts, and in the last decade the relationship between innovation, entrepreneurship, and 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 observed that within them, "The mysteries of the trade become no mysteries; but are as it were in the air…." A large number of empirical studies demonstrate that knowledge spillovers are geographically mediated, which is to say that innovation is found in clusters. As early as Malecki (1980) it was observed that there was regional variation in R&D and from this he 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 in medical instruments. This clustering of innovation is not just a result of production clustering, for even after the geographical concentration of production is accounted for innovations are more likely to cluster geographically in industries where industry R&D, skilled labor, and university research are important inputs (Audretsch and Feldman 1996).

[3] On social embeddedness, see Granovetter (1985). On embeddedness of economic activity in a regional context, see Storper and Salais (1997). In economics, the most recent statement is Krugman (1991) and in business studies, see Porter (1998).

The regional concentration of innovation in particular industries was shown by Jaffe et al. (1993), who found that patents will cite other patents originating in the same location more frequently than they will from outside the location, even after controlling for the existing geography of related research activity. This methodology has been extended by others (Almeida and Kogut 1997; Breschi and Lissioni 2002) with similar results; patent citations are highly localized indicating that there are geographic limits on knowledge spillovers.

The reason there are geographical limits on the ability of such knowledge to be transmitted is variously explained. One such explanation is that cutting-edge knowledge is tacit in nature, and therefore is 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) suggest that such knowledge travels between firms within a cluster through networks of shared practice within which interpersonal interaction is the conduit for such knowledge. Pinch and Henry (1999) use the concept of a community of knowledge as a description of the untraded means of information dissemination found in the British motor sport. It is networks that provide the transmission routes for the knowledge exchanged within a cluster, and because these networks are maintained by social relations 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 as 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 of these actors assist in the operation and creation of firms, and as such they fit into Marshall's second of three distinct reasons why entrepreneurship might be expected to be clustered: namely to have access to specialized inputs and services available in the region.[4]

Among the members of this entrepreneurial support network, only the spatial distribution of venture capitalists has been subject to empirical investigation. Sorenson and Stuart's (2001) investigation of the spatial dimensions of venture capital investment demonstrated that while the bulk of venture capital investing is local, experienced venture capitalists exhibit more dispersed co-investment patterns not only geographically but also industrially. They attribute this result to the fact that network relationships among

[4] See Krugman (1991, pp. 36-54) for a detailed discussion of Marshall's reasons why firms cluster.

VCs, 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 networks that venture capitalists maintained.

Previous research emphasized the role of networks as a means for the transmission of specialized market information and the provision of services to start-ups, though there was little empirical research examining the geography of these networks. This is remarkable, because it is widely accepted that these support networks assisted entrepreneurs in assembling the capital and other resources to launch and expand their firm. This study dramatically extends previous studies that focussed solely on venture capital by examining three other constituents of a start-up's entrepreneurial support network.

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 non-ergodic path development as successful start-ups encourage the growth and the elaboration of the support network and vice versa (Arthur 1994; Storper and Walker 1988). The larger the cluster of start-ups 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 very specific knowledge to evaluate the start-ups, one would expect the support network to be more highly clustered in the region with the greatest number of start-ups. 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 study 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 each of these constituents roughly in their order of assistance to the start-up and importance.

Firm Lawyers

Often the first person entrepreneurs consults 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 any young firm faces. In entrepreneurial, high-technology regions, lawyers often are intimately involved in start-ups from their inception (Suchman 2000). Because of the intimate role that the law firm plays in a start-up, one would hypothesize that a law firm would be located in close proximity to its start-up client. It is more difficult to predict the location of the law firm for start-ups established outside of entrepreneurial clusters. Often, the local law firms have little expertise in assisting

high-technology start-ups, and this may encourage such start-ups to retain law firms from one of the entrepreneurial clusters.

Venture Capitalist Directors

Venture capitalists are an intermediary willing to invest capital in a rusty new venture. Because their stake in the firm is in the form of equity, venture capitalists are actively involved in monitoring their investment. Often they assist in recruiting executives, providing 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 providing information on a wide variety of relevant issues. In order 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), or contemporary corporate banking (Uzzi 1999) in that the human networks within which information is transmitted are vital to business success. Because venture capital firms operate in a tightly knit community and have detailed information of 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). For the startups, the critical venture capitalists are those on the board of directors and because of their monitoring function these would be more likely to be local.

Investment Bankers

Of the investment banks the role comes somewhat later in the life cycle. Their role is to provide advice on financing options or potential merger and acquisitions. Conversely, for the investment banks leading an IPO can be very profitable as the bank retains at least 7 percent of the entire offering as a fee.[5] Historically, the largest and most prestigious investment banks, such as Goldman Sachs and Morgan Stanley have been headquartered in New York City, though, in the 1970s and 1980s a number of smaller boutique investment banks such as Hambrecht and Quist, Robertson Stephens, and Montgomery Securities were established in San Francisco to support high-technology start-ups (during the 1990s they were acquired by larger outside banks). The Boston area also had a number of local investment banks that developed high-technology specialties. During the 1990s, the small San Francisco boutique investment banks were acquired by non-local banks, while contemporaneously the largest New York City investment banks established operations in Silicon Valley (Kenney and Patton 2004; Rogers and Larsen 1984; Borrell 2001). Because of the concentration of investment banks in Silicon Valley, we would

[5] From 1995-2000, many of the investment banks illegally allocated these shares to favored investors in efforts to secure further business or in exchange for preferential fees on other transactions.

expect that local investment banks would service Silicon Valley start-ups. On the other hand, start-ups outside of the Silicon Valley could be expected to be serviced from New York.

Non-Venture Capitalist Directors

The non-venture capitalists on the start-up's board of directors are a diverse group and may fulfill a variety of different roles for the firm. For example, they may be appointed because of specific technical knowledge or business acumen they possess; in these cases the networks within which they are embedded are very important. At other times, they can be executives at firms that are or could become either customers or suppliers, thereby facilitating or cementing a relationship. In certain cases, they may simply be on the board for the reputation effect they create. 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 might be expected that they would be more geographically dispersed than the other actors would.

Data and Methodology

The data used in this paper is drawn from the S-1 registration statement and the 424B prospectus that every firm wishing to make an initial public stock offering (IPO) must file with the U.S. Securities and Exchange Commission (SEC). This data in is the most accurate 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 bankers and the investment banker's lawyer, and the names of its directors including key venture capitalists and other independent board members[6]. These provide a detailed snapshot of the firm at the time it goes public.

The unavoidable shortcoming of the data is that it is available for only a small number of the total firms formed in an industry, because only a very small number of the firms formed in these industries ever mature to the point of being able to undertake a public offering. Therefore, the firms studied here are the most successful start-ups, but the censoring might mean that they are not representative of all start-ups in these industries. However, as Table One indicates our population exhibits roughly comparable spatial distributions to populations that do include all start-ups.

The address of the firm and its lawyer are in the filings. Though we have the name of the investment bank, there is neither an address nor the name of the lead investment banker in the filings. Because we were unable to obtain the individual name of the lead investment banker and because many investment banks have multiple offices, there was no obvious criteria by which to attribute the investment banker to an office. To overcome this problem, we collected anecdotal information on particular deals by

[6] We also have information on the start-up's accounting firm, however we have neither names nor addresses for the lead accountant responsible for the start-up. Therefore we cannot locate the relevant office, though anecdotal information suggests that it is usually in close proximity to the start-up.

investment bankers, and then compared their location with that of the investment banks' law firm as stated in the prospectus. The law firm proved to be an excellent proxy for the lead investment banker's regional location. Thus all the locations for the investment banker are those of their proxy, the law firm.

The SEC requires that each prospectus include a list of its executives and board of directors. This information yielded a list of the independent directors that was parsed into two mutually exclusive sets: The directors affiliated with a venture capital (VC) firm, and the remaining board members that were not venture capitalists. The address and location of all directors was found from information in the prospectus and through Internet searches. Less that five percent of the VC directors could not be located. A precise address was also found for 95.6%, 86.9%, and 81.9% of the non-VC directors in semiconductors, communications, and biotechnology, respectively.[7] The roster of the firms in this study were obtained from the VentureXpert database listing IPOs from June 1996 through the year 2000. The database does not include small businesses filing an SB-2 registration statement rather than an S-1. 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 public offering. According to this criteria, the population included 44 semiconductor firms (SIC Code 3674), 53 telecommunications equipment firms (SIC Codes 3661, 3663, 3669), and 65 biotechnology (SIC Codes 2833-2836) firms. The entire database of 162 firms included 1,275 individuals.

One possible difficulty with our interindustry comparison is that the merchant semiconductor industry having been established in the late 1950s is much older than the biotechnology and telecommunications equipment industries that began in the late 1970s. The notion is that the semiconductor industry has had time to concentrate, while the two younger industries have not had sufficient time to concentrate. This argument appears flawed as the biotechnology industry was more concentrated at its inception than it is today (see Table 1; also, Stuart and Sorenson 2003). Moreover, the semiconductor firms established since the mid 1980s are what is termed "fabless," which means they do not manufacture their semiconductors; they only design and market them (OhUallachain 1997). In a sense, this can be considered a "new" industry. For these reasons, we do not believe that industry age has increased spatial density.

Table 1 about here

This paper largely relies upon the use of states as the regions. However, states such as California, Texas, and even Pennsylvania include more than one economic region. In other cases, regions extend

[7] 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 using the VentureXpert database attribute the investment to the venture capital firm's headquarters (e.g., Stuart and Sorenson, 1999). Because of the attribution of an investment to the headquarters, in these studies extraregional co-investment probably appears greater than it in fact is.

beyond the borders of single states. To control for this, California is divided into Northern and Southern California, though a case can be made for separating San Diego from the greater Los Angeles area. Because Texas and Pennsylvania did not have so many firms, it was decided to treat each of these states as a single region, though in the case of Texas this may overestimate the clustering since both the Austin and Dallas-Fort Worth regions do have firms in our database. In the case of Pennsylvania, nearly all the relevant activity is in the greater Philadelphia area. In terms of interstate clusters, New Jersey and Connecticut were combined with New York; and Maryland and Virginia were combined with Washington, DC. The reasoning for this 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, DC area includes Maryland and Virginia, though she explicitly notes that technical activities may have a microregional spatial configuration.[8]

The geographical 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. The table indicates the regional source of network actor on the horizontal axis, and the regional target (i.e., the firm) serviced by this actor on the vertical axis. As an example, Table 2a there are 27 dyads in which a Northern California

semiconductor firm relied upon the services of a Northern California law firm, there are two dyads in which a Southern California firm relies upon the counsel from Northern California, and one dyad where a firm in the New York region relies upon 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, and two of those three firms were served by law firms from New York, and the other was served by an out of state law firm.

As noted above, one question that can be raised is how representative our sample is of the entire population of venture capital–financed start-ups. Table One compares our data with that of other researchers that have examined the entire population of start-ups and shows that they are quite similar. In addition, in the case of biotechnology Powell et al. (2002) found that funding patterns did not differ between firms before and after going public, providing further support for the contention that our data is representative of the larger population of biotechnology start-ups.

[8] Anecdotally, there is evidence for this in Silicon Valley, also. The biotechnology start-ups 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 non-technology based dot.coms were located in downtown San Francisco. There has been very little attention given to the microregional districts, though this is most likely what struck Alfred Marshall when he was commenting on industry mysteries of the trade being as if they were in the air.

With reference to venture capitalists, our data also differs from the data used by other scholars in that typically use the VentureXpert database that provides them all the investors in each start-up 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 have the responsibility of monitoring the start-up 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). Thus, though we do not have all the VCs, our data captures the most important venture capital relationships.

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 start-ups can be traced to the formation of Fairchild Semiconductor in 1957 and the subsequent proliferation of spin-offs from it and its success. In 1971, Hoefler (1971), an editor at Electronic News, was the first to comment on the proliferation of start-ups 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 et al. 2000). Writing in 1978, Braun and MacDonald (1978: 128) 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.[9] The localization of the semiconductor industry in Silicon Valley is intimately related and strongly, though not solely, responsible for the growth of venture capital in the region.[10]

There has been much research on the clustering of semiconductor firms in Silicon Valley, though not directly dealing with the entrepreneurial support networks. Studies have shown that Silicon Valley has the largest concentration of semiconductor engineers, and that it experiences the greatest intraregional labor mobility (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 [Silicon Valley] indeed [contributes] strongly to the overall localization findings." Smaller, younger semiconductor firms, exactly the ones that are in our population, were more strongly tied to local knowledge networks than were larger firms (Almeida and Kogut 1997). This research concludes that labor mobility is critical for the transference of knowledge in Silicon Valley, and, more important for our

[9] Few authors discussing the development of the Silicon Valley semiconductor industry have remarked upon the importance of the decision by Fairchild and its progeny to use silicon as their substrate, rather than the then prevalent germanium used by East Coast firms (Braun and MacDonald 1978).

[10] For a history of the development of the venture capital industry in the Silicon Valley region, see Kenney and von Burg (1999).

research, a method by which small start-up firms can attract experienced employees to aid in the growth process. In other words, the knowledge and individuals that is now material for starting a semiconductor firm is especially densely located in Silicon Valley

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

The start-ups in the semiconductor industry have remained remarkably concentrated in Silicon Valley (see Table One) with 27 of the 44 in our database being in Silicon Valley. The others were scattered in different regions. This pattern exhibits the typical clustering suggested by the literature on Silicon Valley, whereby an industry concentrates in a single location. Given the current concentration and its persistence over time, one would expect that the support network would also have 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 service all the local startups. Second, Silicon Valley law firms serve three 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 semiconductor firms.

Table 2a, b, c, and d about here

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. Most interesting, only Silicon Valley startups had attracted foreign venture capitalists (Taiwan (4), Israel (2), and one each from France, Switzerland, and the United Kingdom on their boards of directors).[11] Though the reasons for having foreign venture capitalists on the boards of directors may be different in each case, this suggests that foreign venture capitalists have great interest in funding Silicon Valley semiconductor firms. There is also

[11] Though these foreign firms indicate in their addresses that they are located overseas, very often they will have a small office in the Silicon Valley region that serves to monitor the investment (Kenney et al. 2002).

evidence that these foreign venture capitalists participate in deals through ethnic (nationality) connections with the entrepreneurs (Kenney et al. 2002; Dossani 2002). The Silicon Valley is the national center for semiconductor startups and thus attracts investment from venture capitalists both within the region and outside the region. In terms of lead investment bankers (Table 2c), in percentage terms, Silicon Valley is dominant and supplies investment banking services more widely than even legal services. What this suggests is that the investment banks have their semiconductor practices in Silicon Valley. The widest dispersion was the non-VC directors (Table 2d). But even in this case Silicon Valley firms had the broadest national networks and secured directors from around the nation, even while it provided the greatest number of non-VC directors to other regions.

The centrality of Silicon Valley in the semiconductor industry start-ups is remarkable. It attracts far greater number of venture capitalists and non-VC directors from the greatest number of locations including overseas. Simultaneously, it also provided directors, both VC and non-VC, to the greatest number of locations. Perhaps, most significant was that it provided the most intimate service, lawyers, to other regions. Finally, the Bay Area was a far more important location for investment bankers taking semiconductors firms public than was Wall Street. Our data indicate that the semiconductor industry and its support network are extremely concentrated in Silicon Valley.

The Telecommunications Equipment Industry

The inception of the start-up economy in telecommunications equipment is difficult to precisely date. However, the first significant wave of start-ups commercializing telecommunications at the equipment 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 early spin-outs (Burg 2001; Chesbrough 2003). However, MIT and DEC in the Boston area were also research centers and Boston had a number of spin-outs. At that time there were already the large incumbent telecommunications equipment suppliers such as AT&T's Western Electric (renamed Lucent), the national equipment suppliers to their national telephone provider (such as, Alcatel, Northern Telecom, Fujitsu, NEC, Ericsson, and Siemens). The computer network equipment business was so small that it was of little commercial interest to these established firms (Burg 2001). The rapid rise of data traffic, first in the local area networks and then in wide area networks, such as, but not limited to the Internet, massively expanded existing markets and created new markets.

There have been few studies of the geography of the communications equipment start-ups. However, a genealogy of the most important pioneering computer networking equipment startups through 1989 shows that fifteen were located in Silicon Valley, seven in the Boston area, and four more scattered around the nation (Kenney and Burg 1999). The next significant event was the founders of Cisco leaving Stanford to commercialize a router for wide area networks (Kenney 2004). The

telecommunications equipment industry continued to evolve rapidly with wave after wave of start-ups seeking to commercialize each new technical advance. The most significant of these would prove to be Cisco Systems (Kenney 2004)

The vast majority of these firms were funded by venture capitalists, though a few of the early ones were bootstrapped.[12] 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 (Burg 2001), an advantage that in network industries where standards are very important can lead to outsize gains (Arthur 1994). Firms such as Cisco, Synoptics, 3Com, and Wellfleet had extremely successful IPOs, and like Fairchild later became the source of new entrepreneurs. Though Silicon Valley and Boston were leaders in the 1980s, as the technology evolved, other regions that had significant human resources also spawned start-ups. Other regions that had capable engineers included New Jersey, the home of Lucent's Bell Laboratories and Dallas, Texas where a number of telecommunications equipment manufacturers had located to service MCI. For telecommunications equipment, the expertise was more widely dispersed than in the case of semiconductors.

In our data 41.5 percent (22 of 53 firms) were located in the Bay Area. However, there were firms in other regions including Southern California, Washington, DC, Texas, and Massachusetts. As in other industries, law firms were concentrated in close proximity to their start-up clients, with 45 out of 53 law firms being provided locally, including all nine of the firms outside the top six (Table 3a). Interestingly, Southern California provided law firms for two Silicon Valley start-ups, while Silicon Valley provided legal services for three firms outside the region. In terms of venture capital, Northern California provided venture capital to other locations (Table 3b). What is particularly interesting is the dominance of Northern California venture capitalists in funding Southern California start-ups. Northern California, despite the fact that it only had 41.5 percent of start-ups provided 56 percent of the venture capitalists. In effect, they serviced the entire country. However, as in the case of semiconductors, Silicon Valley also attracted more outside venture capitalists than did any other location. Though New York had few telecommunications equipment startups, it provided venture capital services especially to the regions that had little clustering. Foreign venture capitalists were less in evidence than in semiconductors, as there were two investors from Taiwan in Northern California, one from Canada in Southern California, and one from France in Washington, DC. As a result of other locations providing services, the start-ups were more widely distributed than were the venture capitalists that supported them. The investment bankers in Northern California were very important, but largely handled deals within the region, while those in

[12] For a discussion of the role of venture capitalists in funding communications equipment firms, see Burg and Kenney (2000).

Southern California, Boston and New York provided assistance to the firms in their region and outside the region (Table 3c).

Table 3a, b, c, and d about here

The supply of non-venture capitalist members of Boards of Directors was fascinating as Silicon Valley provided only nine 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 non-VC board members (Table 3d). Likely, this is the result of Silicon Valley start-ups forming strategic alliances with extra-regional established telecommunications equipment firms from outside the region (Soh and Roberts 2003) through which the extra-regional firms also secured a board membership. Southern California actually provided more non-VC board members to firms outside its region than did Northern California. Boston, New York, Texas, and Washington, DC also provided some board members to firms outside regions, though in each case the number was either five or six and thus only about half of the numbers provided by either of the two California regions.

In this industry, 84.9 percent of the lawyers were from the same region as the start-up. This dropped significantly in the case of the venture capitalists where only 49 percent were from within the region, and similarly only 47 percent of the non-VC directors were in the same region as the firm. Investment bankers were more regionally proximate as 60.4 percent were from within the region. Clearly, the telecommunications equipment industry is concentrated in Silicon Valley, however a few of the other regions do have noticeable concentrations of successful firms and some of the 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 might have the potential for commercial exploitation. This contrasts with the other two industries because "star" university scientists were critical in the early days of the industry's development. The location of the universities employing these star scientists was a determinant factor in the location of the early start-ups (Zucker et al. 1998; Zucker et al. 2002). Key scientists served on scientific advisory boards and even the firms' board of directors (Kenney 1986; Krimsky 2003). Firm founders or the chair of a firm's Scientific Advisory Board (SAB) were much more likely to be located in close proximity to the firm than other Advisory Board members (Audretsch and Stephan 1996). In other words, proximity to universities (and academic research institutes) was central to the formation of the early biotechnology start-ups 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 et al. 1998; Stuart and Sorenson 2003). However, Stuart and Sorenson (2003) found that as the biotechnology industry matured, proximity to factors such as universities, incumbent firms, and venture capital declined in importance.[13] This is interpreted to mean that the basic knowledge necessary to establish a biotechnology firm has become more generalized. An alternative explanation is that the capability and desire to start firms on the basis of university knowledge has become more widely diffused, and the ability to access distant actors in the entrepreneurial support network has become easier.

The most comprehensive and detailed study of the spatial dimensions of the relationship between biotechnology firms and venture capitalists is Powell et al. (2002). Their data indicates the spatial patterns of funding have changed from 1988 when there was a very simple pattern of funding in which New York venture capitalists funded firms locally, in Boston, and 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 had become 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 (1999) they find that for the biotechnology firm, local VC funding creates a "reputation" effect that attracts venture capital to the firm from outside the region.

The biotechnology firms are more widely dispersed than in the other two industries. The two largest concentrations are in Northern California and Boston, something that is not surprising considering the concentration of first-rank research institutions in both locations. Among lawyers, 67.7 percent are located in the same region as their client with Boston and New York provided the greatest number of lawyers to extra-regional clients (Table 4a). In both of these regions, the exportation of legal services is a substantial portion of all the services. Interestingly, Northern California was largely self-sufficient. In the case of venture capital, Northern California venture capitalists serviced twice as many extraregional firms as those internally, even while it received approximately 1 ½ times as many venture capitalists as it provided internally (Table 4b). Boston had a similar pattern. What was most remarkable was New York, which had only two start-ups, however it provided venture capital to other locations in 35 cases. Put differently, it was 17 ½ times more likely to provide venture capital outside of its region as inside it. In only 24.7 percent of all the cases did venture capitalists invest in local firms. There was also less investment by foreign venture capitalists as these were only three investments. In summation, 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 also are

[13] For a discussion of regions and biotechnology, see Cooke (2001).

significant extra-regional investors. In the case of biotechnology, the important regional centers of venture capital invested nationally, and intra-regional investing was less important than extra-regional. Investment banking was significantly less complicated as New York was clearly dominant providing 50.8 percent of all the investment bankers for the industry (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 for both venture capital and investment banking, New York was an important source of service despite the fact that it did not have a large concentration of biotechnology firms.

Table 4a, b, c, and d about here

The pattern for non-VC directors was complicated (see Table 4d). As was the case for venture capitalists and investment bankers, the New York area boasted the largest number of non-VC directors providing them to every other region. As in the other cases, Silicon Valley was the largest attractor of outside non-VC directors attracting proportionally more than either Massachusetts or New York. Moreover, the biotechnology industry was the only one in which the "other" category in both provision and attraction of non-VC directors was so significant. This 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.

Inter-Industry Comparison

The previous three industry sections have described the history of the three industries being studied and examined the geography of the entrepreneurial support networks in each industry. We have shown that in terms of location the semiconductor industry was the most concentrated and the biotechnology industry the least concentrated with telecommunications equipment being in-between. This section examines the proximity of the firms to the members of their support network in the three industries.

To compare the spatial distribution of the actors across industries, we separated each dyad into those where the members were within 50 miles of each other, and those where they were more than 50 miles apart.[14] Table 5 shows the distribution of these dyads 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 that plots the distances between dyads for all the members of

[14] All of these distances are from physical address to physical address with the following exceptions: First, we are using the proxy for the location of the investment banker, i.e., the investment banker's lawyer's address. Second, in 19 domestic cases we were unable to exactly establish a person's address, but we were able to locate in which city or county they resided and could therefore determine if they were more or less than 50 miles from their firm. In addition, all foreign actors were assumed to be over 50 miles away. Only 71 actors out of a total of 1,113 could not be located at all.

the entrepreneurial support network, 50 miles was a plausible separation point for distances.[15] Almost half of all members of a support network (48.9 percent) are within 50 miles of their firm. Beyond 50 miles the distribution is mildly bimodal, with a slight concentration from 100 to 450 miles, and another concentration from 2,400 miles and beyond. All foreign-based directors are considered as being 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 as close, while those over this distance are far away.

Figure 1 about here

After separating the dyads into greater than or less than 50 miles apart, we then conducted Chi Square analyses to determine whether these firms came from underlying different populations. The results indicate whether the industries differ statistically from each other regarding the proximity of their respective support networks.

Prior to discussing 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 concentrated overall with 93.2 percent of all 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, though 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 of the firms. This means that no single region was dominant in biotechnology, whereas in the other two industries Northern California was dominant.

Firm Lawyers

The results of our chi-square analysis indicate that there is no statistical difference between the three industries in the case of the location of the start-up and the start-up law firm (see Table 6).[16] The provision of legal services was spatially very close to the entrepreneurial firm and is the most highly localized component of the support network. This is not surprising, because of the intimate relationship between the law firm and the start-up. Suchman (2000) studied Silicon Valley law firms and found that they were intimately involved in the affairs of their clients playing the role of "counselors" in the early life of the firm assisting in a variety of ways such as providing introductions to venture capitalists, etc. This intimacy argues against long-distance relationships. However, in a relatively number of the cases, 35 out of a total of 162, or 21.6 percent, start-ups do retain law firms from outside their region. In this case, the major regions provide services to peripheral start-ups. In this case, it is likely that the start-up

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

[16] When these industries are compared as a group, in addition to being compared pairwise, this same χ^2 result holds. That is, the proximity of firm lawyers, 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.

may be unable to find the necessary expertise locally, and thus must secure the expertise from a major center. Though not statistically significant, the use of extra-regional law firms was greatest in biotechnology, which is also the industry with the greatest dispersion.

Table 5 about here

Table 6 about here

Venture Capitalist Directors

In the case of venture capitalists, the previous literature led us to expect that there would be a significant level of co-location particularly for the venture capital firms (Florida and Kenney 1988; Sorenson and Stuart 2001; Gompers and Lerner 1999). Silicon Valley's importance as a national center of venture capital is evident.[17] This is particularly true for the semiconductor and communications firms, while 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 to the firm than was telecommunications equipment, as Table 6 shows there was no significant difference in proximity. The semiconductor start-ups also relied far more heavily on foreign venture capitalists than did any other industry. In semiconductors, 11 percent of the venture capitalists were foreign, while in telecommunications equipment and biotechnology only 4.0 percent and 2.8 percent, respectively, were foreign. On the other hand, despite this foreign involvement, in both semiconductors and telecommunications equipment, the venture capitalists were significantly closer to the firm than was the case in biotechnology (see Table 6). These results suggest that for biotechnology the venture capital portion of the support network is significantly more extra-regional than for the two electronics-based industries. One reason for this might be that during the last decade a group of venture capitalists specializing in the life sciences emerged. Given the dispersal of the biotechnology startups, it is likely that very few venture capitalists could survive on biotechnology deals from their region alone, therefore there was much extraregional investing. Firms outside Northern California, Massachusetts, and New York relied on these regions for venture capital services as these three regions provided over half of all venture capital directors.[18]

Up to this point we have been looking at the individual venture capitalists that sit on the boards of these firms. One might ask if these same patterns of proximity hold if we shift our attention to the individual firms themselves. Sorenson and Stuart (2001) have observed that VC firms are more likely to fund a spatially distant firm if another VC with whom they have had experience is involved with the firm,

[17] For a discussion of the history of venture capital in Silicon Valley, see Kenney and Florida (2000).
[18] Northern California, Massachusetts, and New York together provided 45.0 percent, 61.1 percent, and 66.7 percent of all VC directors to semiconductor, communications, and biotechnology firms outside these three areas respectively. By comparison, these same percentages for non-VC directors are 38.5 percent, 27.9 percent, and 37.8 percent.

and if that firm is geographically close. We might expect that such reliance by distant VCs on a geographically close VC director to monitor and advise the firm may play a role in the three industries studied here. To determine this we restricted our attention to those firms that had at least one VC on their board of directors, and then looked at the proportion of these firms having at least one VC director within 50 miles of the firm.[19] The proportions were 73.0% of such semiconductor firms, 57.5% of such telecommunication firms, and 44.4% of such biotechnology firms that had at least one venture capitalist within 50 miles. Chi-square analysis indicated that the differences between semiconductors and telecommunications, and telecommunications and biotechnology were not significant, the difference between semiconductors and biotechnology was significant at the 0.01 level.

Investment Bankers

In investment banking the support network is 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 very substantial degree, telecommunications equipment, Silicon Valley was self-supporting and even provided conventional banking services to other regions. This is not remarkable, because in these two industries, Silicon Valley remains the overwhelming national center of start-ups. Therefore, investment banks have been attracted to the region as a source of public offerings. The investment bankers that handled IPOs were more concentrated than were the start-ups. This suggests that the investment banking function could be and often was provided remotely in telecommunications equipment and particularly biotechnology. Silicon Valley is significant because, over time, it has built such a powerful electronics base that the investment banks such as Goldman, Morgan Stanley, and J.P/ Morgan located their electronics-based practices in the region.[20] (As a result for semiconductors, SV then provided investment banking services this capacity attracts not only local firms, but also extraregional start-ups.) Awkward sentence this was also the case in telecommunications equipment, though to a lesser degree. Interestingly, in biotechnology the pattern of Silicon Valley discharging its own investment bank functions does not hold, while it does undertake some investment bank 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 et al. 2002 and Stuart and Sorenson 2003), there is no overwhelming attractor for the investment banks, therefore they would be more likely to be located in the investment banking cluster, New York. Thus, though Northern California has the largest cluster of biotechnology firms, it has never achieved the dominance that it has in electronics-related industries.

Non-Venture Capitalist Directors

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

[20] For a discussion of the co-evolutionary development of Silicon Valley, see Kenney and Patton (2004).

In electronics and semiconductors the non-VC board members were more dispersed than any other constituent of the entrepreneurial support network, in large measure, this was due to the large number of extraregional directors serving Silicon Valley firms. Interestingly, in biotechnology the non-VC directors were more likely to be in the region of the firms they served than were the VC directors and investment bankers. Despite this wider relative dispersion of non-VC directors in the two electronic industries, these directors were still more closely located to their client firms than was the case in biotechnology. Among the top 6 regions, 68.3 percent of semiconductor, 54.7 percent of telecommunications, and 40.3 percent of biotechnology non-VC directors were provided locally. One possible explanation for the large number of extregional directors is that Northern California start-ups are the most sophisticated and thus understand very well how to make their firm most attractive for potential purchasers of their stock, and thereby work very hard to capture the "reputation" benefits of a strong board of directors (Beatty and Ritter 1986; Megginson and Weiss 1991; Baker and Gompers 2003).

In comparing the proximity of the directors, we would have hypothesized that VC directors would be more likely to be close to the firms than would the non-VC directors. However, we found that this was not the case.[21] Both directors shared similar patterns of proximity to the firms. In other words, in the electronics-based industries 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 further illustrates the differences in the entrepreneurial support networks in biotechnology and the electronics-based industries.

These comparisons demonstrated the differences in each industry, and, in particular, the differences between electronics and biotechnology. The concentration of the support network for electronics in Northern California is striking, and undoubtedly is a case of a co-evolution of the industry and support network (Kenney and Patton 2004). Another facet that was quite interesting is the manner by which Northern California attracted venture capitalists from around the world and non-VC board members from other areas. This suggests that the region has developed a mechanism for overcoming what might 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 they might also be drawing upon networks in their regions of origin (Dossani 2002). If the electronics-based industries are concentrated, then biotechnology is, conversely, comparatively dispersed. Previous scholarly research suggests that this is 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) or geographic concentration process that Storper and Walker (1989) suggest does not operate as strongly and likely will not operate as

[21] When comparing the proximity of VC and non-VC directors, χ^2 results indicate that there is no significant difference between these two types of directors' proximity in each of these industries.

long as universities continue to generate commercializable science. The ability to establish start-ups in regions missing important components of the support network is facilitated by the actors in the entrepreneurial support networks' willingness to work with distant firms. As a corollary, this permits the concentration of support network members especially those in the financial fields in New York City. It also suggests that perhaps too great emphasis has been placed on the significance of proximity, at least, in the case of biotechnology.

Discussion and Conclusion

This cross-industry comparison of the entrepreneurial support networks in these three industries suggests that conclusions about networks drawn from single industries can be misleading. Comparative research provides an antidote to generalizations from the studies of individual industries. Though biotechnology exhibits considerable clustering of both firms and support networks, this study leads us to question whether there really are global-class biotechnology clusters. This is even truer, if we consider an entrepreneurial cluster as having a number of components of the support network.

Clustering in biotechnology (and, perhaps, 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 might draw them together. Thus the normal cluster effects may not be sufficient to create the winner-take-all regional dynamics predicted by scholars such as Arthur and Storper and Walker. If the centripetal forces are not so 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 suggests that the literature on biotechnology clustering is, in some way, missing the point that these clusters are far less significant than those in some other high-technology industries are.

For policy-makers our results are very important. They indicate that it may be far easier to encourage the establishment of a number of biotechnology firms than it would be a semiconductor or telecommunications equipment firms; but that a powerful cluster effect that includes the emergence of a support network may never occur. The difficulties of entering the electronics industries is demonstrated by both the concentration of support network assets, 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 such clusters in other regions should 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 the skilled personnel able to establish new firms, there may

be little opportunity to initiate a virtuous circle of firm success, IPOs, spin-offs, and yet more successes that facilitate the creation of strong local entrepreneurial support networks. The source of the seeds for new firms appears to have a great influence on cluster and support network dynamics.

This suggests that two economic development strategies might be possible. First, a strategy of improving the local university's biomedical capabilities might be more successful as an economic development policy than trying to develop an electronics cluster. Second, it should be possible to accomplish this without having to co-localize all or even most of the support network actors, since they are available from outside the region. Further research should be able to answer whether a similar situation holds in other biomedical fields. However, it also suggests that any cluster developed will not be extremely powerful as an economic development tool, because it will not become truly dominant. Entry might be relatively easy, however dominance will likely be unobtainable.

Turning to the entrepreneurial support network actors, we find 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 proximity patterns observed here between firms that have gone public and these network members. Start-ups in industries whose clusters are coincident with these three regions enjoy significant 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 powerful impact on the establishment of successful startups there. This highlights the notion that entrepreneurship is the primordial requirement (Feldman 2001). While telecommunications assumes something of an intermediate case between semiconductors and biotechnology, biotechnology is characterized by an economic geography quite different from semiconductors.

Because biotechnology start-ups are more dispersed outside the venture capital and investment banking concentrations, biotechnology start-ups rely more on these services being provided extraregionally. The co-location of venture capital and biotechnology start-ups 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 entrepreneurial support network actor that was the most likely to maintain close proximity across all three of these industries was the start-up firm's lawyer. These results point to the centrality of the law firm in the local support network and suggests that those interested in encouraging technology-based entrepreneurship may have underestimated the significance of law firms in the firm formation process. Economic development professionals might consider how they could mobilize local law firms to support the entrepreneurial process as it seems that they are the single support network actor that seems to be the most localized.

The economic geography of entrepreneurship and support networks for such entrepreneurship is a fertile area of research for economic geography. Unfortunately, today the preponderance of the research is underway outside of economic geography. Our contribution has demonstrated the ways in which empirical data on spatial location can be used to better understand the locational dimensions of organizations providing services to startups. We view this paper as the beginning of an effort to test and improve theories concerning the spatial determinants of entrepreneurship.

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Table 1: A Comparison of the Location of the Firms in this Study with Other Studies

Semiconductors	Kenney & Patton (2004)	Schoonhoven et al. (1989) (all start-ups 1978-1986)	
	n = 44		
Northern CA	61.4	70.4	
Southern CA	11.4	8.3	
NY/NJ/CT	6.8	3.7	
	4.6 - MA-OR-CO (tied)	3.7 - Texas	
		2.8 - Colorado	
Other	6.6	11.1	
Telecom Equip.	Kenney & Patton (2004)		
	N=53		
Northern CA	41.5		
Southern CA	9.4		
DC/VA/MD	9.4		
MA	7.6		
	5.7 - TX-WA (tied)		
Other	20.7		
Biotechnology	Kenney & Patton (2004)	Stuart and Sorenson (2003) in 1995	Kenney (1986: 134) in 1984
	N=65	(N = 1,278)	(N = 81)
Northern CA	18.5	15.7	29.6
MA	16.9	12.6	12.3
NY/NJ/CT	12.3	15.9	16.1
Southern CA	7.7	12.2	13.6
	6.2 – DC-PA (tied)	7.6 – DC	7.4 – DC
Other	32.2	36	34

DC = DC/VA/MD

Source: Author's compilation from sources cited.

Table 2a, b, c and d: The Relationships between Semiconductor Firms and Support Network Actors

Semiconductor Lawyers Source

Target	N. CA	S. CA	MA	NY	TX	OR	Other	Foreign	Total
N. CA	27	0	0	0	0	0	0		27
S. CA	2	3	0	0	0	0	0		5
MA	0	0	2	0	0	0	0		2
NY	1	0	0	2	0	0	0		3
TX	0	0	0	0	2	0	0		2
OR	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

38 out of 44 on the diagonal (actors provided internally, or within state) or 86.4 percent.

Semiconductor Venture Capital

Target	N. CA	S. CA	MA	NY	TX	OR	Other	Foreign	Total
N. CA	34	0	1	3	0	0	1	9	48
S. CA	1	3	0	0	0	0	1	0	5
MA	2	0	3	0	0	0	1	0	6
NY	1	0	1	3	3	0	0	0	8
TX	1	0	0	1	6	0	0	0	8
OR	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

49 out of 73 domestic actors on the diagonal or 67.1 percent.

Semiconductor IB Source

Target	N. CA	S. CA	MA	NY	TX	OR	Other	Foreign	Total
N. CA	26	1	0	0	0	0	0		27
S. CA	3	2	0	0	0	0	0		5
MA	0	0	2	0	0	0	0		2
NY	1	0	1	1	0	0	0		3
TX	0	0	0	1	0	0	1		2
OR	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

32 out of 44 on the diagonal or 72.7 percent.

Semiconductor Non-VC Director

Target	N. CA	S. CA	MA	NY	TX	OR	Other	Foreign	Total
N. CA	42	2	2	2	1	1	9	10	69
S. CA	5	6	1	0	0	0	0	0	12
MA	1	1	0	1	0	0	0	0	3
NY	3	0	1	2	0	0	2	2	10
TX	0	0	0	1	1	0	0	0	2
OR	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

56 out of 96 domestic actors on the diagonal or 58 percent.

Tables 3a, b, c, and d: The Relationships between Telecommunications Equipment Firms and Support Network Actors

Telecommunications Lawyers

Target	N. CA	S. CA	MA	NY	TX	DC	Other	Foreign	Total
N. CA	20	2	0	0	0	0	0		22
S. CA	0	5	0	0	0	0	0		5
MA	0	0	4	0	0	0	0		4
NY	0	0	0	1	0	0	0		1
TX	1	0	0	0	2	0	0		3
DC	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

45 out of 53 on the diagonal or 84.9 percent.

Telecommunications Venture Capital

Target	N. CA	S. CA	MA	NY	TX	DC	Other	Foreign	Total
N. CA	37	2	0	1	1	0	1	2	44
S. CA	6	0	0	2	0	0	0	1	9
MA	1	0	3	0	0	0	0	0	4
NY	0	0	0	1	0	0	0	0	1
TX	1	2	0	0	1	0	0	0	4
DC	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

47 out of 96 domestic actors on the diagonal or 49.0 percent.

Telecommunications IB Source

Target	N. CA	S. CA	MA	NY	TX	DC	Other	Foreign	Total
N. CA	18	3	0	1	0	0	0		22
S. CA	1	4	0	0	0	0	0		5
MA	0	0	4	0	0	0	0		4
NY	0	0	0	1	0	0	0		1
TX	1	0	0	0	2	0	0		3
DC	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

32 out of 53 on the diagonal or 60.4 percent.

Telecommunications Non-VC Director

Targe	N. CA	S. CA	MA	NY	TX	DC	Other	Foreign	Total
N.	29	5	0	2	2	2	10	6	56
S. CA	1	6	0	0	0	1	1	1	10
MA	0	0	6	1	0	1	0	0	8
NY	0	0	0	1	0	0	0	0	1
TX	1	1	0	0	1	0	4	0	7
DC	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

55 out of 117 domestic actors on the diagonal or 47.0 percent.

Tables 4a, b, c, and d: The Relationships between Biotechnology Firms and Support Network Actors

Biotechnology Lawyers Source

Target	N. CA	S. CA	MA	NY	PA	DC	Other	Foreign	Total
N. CA	10	0	0	0	0	0	2		12
S. CA	2	2	1	0	0	0	0		5
MA	0	0	9	2	0	0	0		11
NY	0	0	3	5	0	0	0		8
PA	0	0	0	0	4	0	0		4
DC	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

44 out of 65 on the diagonal or 67.7 percent.

Biotechnology Venture Capital

Target	N. CA	S. CA	MA	NY	PA	DC	Other	Foreign	Total
N. CA	8	0	3	6	0	0	2	0	19
S. CA	2	1	1	3	0	0	0	0	7
MA	3	1	8	10	0	0	1	1	24
NY	0	0	3	2	0	0	0	0	5
PA	1	0	0	6	2	0	3	1	13
DC	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

26 out of 105 domestic actors on the diagonal or 24.8 percent.

Biotechnology IB Source

Target	N. CA	S. CA	MA	NY	PA	DC	Other	Foreign	Total
N. CA	6	3	0	2	0	0	1		12
S. CA	3	1	1	0	0	0	0		5
MA	0	0	6	4	0	0	1		11
NY	0	1	1	6	0	0	0		8
PA	0	0	0	4	0	0	0		4
DC	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

19 out of 65 on the diagonal or 29.2 percent

Biotechnology Non-VC Director

Target	N. CA	S. CA	MA	NY	PA	DC	Other	Foreign	Total
N. CA	12	4	4	5	0	2	8	4	39
S. CA	2	8	1	3	1	1	0	0	16
MA	0	2	11	8	0	0	4	0	25
NY	2	3	1	13	1	0	1	2	23
PA	1	0	0	5	5	0	2	0	13
DC	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

69 out of 175 domestic actors on the diagonal or 39.4 percent

Table 5: Proximity of Support Network Constituents to Firms

	Semiconductors		Telecommunications		Biotechnology	
Firm						
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%
VC						
Directors						
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%
Non-VC						
Directors						
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%

Table 6: Chi-Square Analysis of Differences of Actors Across Industries

Chi-Square Comparisons by Industries across Actors						
		Semiconductors		Communications		Semiconductors
		vs.		vs.		vs.
		Communications		Biotechnology		Biotechnology
Firm		0.22751		0.8614		1.84804
Lawyers		n.s.		n.s.		n.s.
VC		2.13361		7.49424		16.50211
Directors		n.s.		0.01		0.001
Investment		4.54264		6.61173		20.84674
Bankers		0.05		0.05		0.001
Non-VC		2.97184		1.05965		8.25676
Directors		0.1		n.s.		0.01

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

Figure 1: Histogram of the Distances between Each Dyad Pair in Each Industry