The spatial configuration of the entrepreneurial support network for the semiconductor industry

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This study is the first to examine the spatial location of different actors in the entrepreneurial support network for high-technology start-up firms. The actors included in this study are lead venture capitalists, independent members of the board of directors, investment bankers, and law firms. Using data based on 44 semiconductor initial public offerings, the geographical location of these newly public firms and the actors in their support network is mapped, and the spatial relationships between these firms and their network are examined. It was found that the geographical proximity between these actors and the firms they support varied significantly, with a firm's legal counsel being the most proximate, followed by investment bankers, venture capitalists, and independent directors.

1. Introduction

Theory and recent research demonstrates that entrepreneurship is a spatially and socially embedded activity.[1] In certain regions, dense support networks of institutions dedicated to assisting entrepreneurial start-ups have been established and a wide variety of authors have given credit to these networks for supporting regional entrepreneurship (Saxenian, 1994; Kenney and von Burg, 1999; Bahrami and Evans, 2000). There has been much discussion of the role of networks in entrepreneurial activity; however, there has been little study of what we term the 'entrepreneurial support networks' consisting of various actors that provide legal, financial, and advisory support to a fledgling firm. This study examines the spatial and network proximity of four key actors, lawyers, venture capitalists, investment bankers, and other members of the board of directors in a start-up firm's growth. Put differently, our goal is to understand how closely the support network actors are clustered to the firm they are assisting.

As Marshall (1890) recognized, many, but not all, industries exhibit a strong clustering effect (see also, e.g., Storper and Walker, 1989; Porter, 1990, 1998), and there has been significant quantitative research of this clustering phenomenon across industries (Swann and Prevezer, 1996).[2] The research on entrepreneurial support networks, although, has been hampered by a lack of empirical data containing spatial variables and identifying the relationship between various actors (i.e., venture capitalists, law firms, and investment bankers) and the start-up firm. Thus, this research usually has been qualitative and anecdotal, or when quantitative, limited to certain high technology industries, especially biotechnology.

For this research we have selected the quintessential high-technology industry, semiconductors, which have reached a stage in their development where they are able to offer stock to the public

through an initial public offering (IPO). Public offerings is but one path a successful start-up may choose, the others being remaining as a private firm or being acquired or merging with another company. The importance of a public offering is that that it allows outside observers access to the inner workings of the new firm. This access is possible through the documents that a firm going public must submit to the US Securities and Exchange Commission (SEC), and it is these documents that provide the basis of this study.

In the first section some of the issues in the literature on clustering are discussed, particularly the role of geographical proximity in the exchange of tacit information. The actors that make up the entrepreneurial support network will also be discussed in some detail. This is followed by a section providing some context and background on the semiconductor industry and its foremost cluster, Silicon Valley. Here some stylized facts regarding the geography of the constituent actors of the firm's support network will be presented in the form of hypotheses that will be addressed in this study. The next section of the paper discusses the data and methodology used, while the fifth section presents the empirical results, including a discussion of our findings regarding the hypotheses previously advanced. The conclusion reflects upon the geography of entrepreneurial support networks in semiconductors and what this tells us about clustering.

2. Economic clusters and entrepreneurial support networks

The tendency of different types of economic activity to concentrate geographically is a widely observed phenomenon over time and across countries. These concentrations of activity are most frequently referred to as clusters or industrial districts, and the relationship between innovation, entrepreneurship, and geography of these clusters has attracted the attention of academics from a variety of disciplines in the last decade. The importance of industrial clustering for firm growth and innovation has been widely noted beginning with Marshall (1890), extending through Piore and Sabel (1984) to contemporary geographers (Scott, 1993; Storper, 1995; Gordon and McCann, 2000; Martin and Sunley, 2003) and others (Porter, 1998; Benneworth and Henry, 2004).

Krugman (1991), in a restatement of Alfred Marshall's observations from 1890, argues that there are three distinct reasons for localization. First, clusters allow for a large market of workers with highly specialized skills. For many firms such skilled labor can only be found within a cluster. Second, a cluster supports a wide range of specialized local suppliers of inputs and services. Again, some specialized inputs are only readily available in clusters. Technological spillovers, the tendency for knowledge to spill over from firms and individuals within a cluster, yet be geographically bounded by the cluster, is given as a final reason for industrial localization.

The literature investigating clusters has found that both traded and untraded interdependency benefits are responsible for the success of these regional economic agglomerations (Porter, 1990; Storper, 1995). Porter (1998), in conclusions not very different from those of Paul Krugman above or economic geographers such as Walker (1985, 1988), identified three broad ways in which clusters affect competition. First, the externalities present in a cluster operate to increase the productivity of all member firms. Second, the cluster accelerates the innovative capacity of its firms. Third, the concentration of specialized skills and knowledge within the cluster reduces the barriers to entry and facilitates new firm formation. Baptista and Swann (1998) found evidence to suggest that all of these factors are at work and that innovation, firm entry, and growth are all stronger in clusters. In qualitative work directed at particular industrial clusters, Kenney and von Burg (1999) have argued that these benefits are responsible for the success of innovative regions such as Silicon Valley and Route 128. Saxenian (1994) takes this further suggesting that the interactive nature of the Silicon Valley environment is the reason that Silicon Valley was more successful than Route 128.[3]

2.1. Proximity and the exchange of tacit information

Audretsch (2000) has observed that an irony of globalization is that as technological advances in communication have drastically reduced the cost of transmitting information over distance, the perceived importance of geographically bound clusters of economic activity as engines of innovation and global competitiveness has grown. The ability to send information almost costlessly anywhere in the world should tend to lead to the death of distance (Cairncross, 1997); yet, distance in the exchange of knowledge among economic

actors is of great importance for a large number of such relationships (Brown and Duguid, 2000). The importance of distance, then, derives from the attributes of the knowledge being transmitted. Knowledge, or information, that can be easily standardized and codified can be sent, and understood, over distance at very low cost. Knowledge that is difficult to articulate and is tacit in nature is more open to interpretation and uncertainty and therefore relies upon face-to-face interaction to be transmitted effectively (Feldman, 2000).

Within clusters technological knowledge spills over to such an extent that Marshall (1890) exclaimed that within them, 'The mysteries of the trade become no mysteries; but are as it were in the air. . ..' Although Krugman (1991) expressed skepticism that such knowledge spillovers could be empirically analyzed as a reason for clustering as they leave no paper trails, a large number of empirical studies have demonstrated that knowledge spillovers are geographically mediated, which is to say that innovation is found in clusters. As early as 1980 it was observed by Malecki (1980) that there was regional variation in R&D and from this he argued that there were significant differences between the ability of regions to innovate. Feldman (1994), using data collected by the Small Business Administration, found that innovations in particular industries were highly concentrated in states such as California and Massachusetts for electronics and New Jersey and New York for medical instruments. Audretsch and Feldman (1996) found that even after the geographical concentration of production is accounted for, innovations are found to cluster in industries where industry R&D, skilled labor, and university research are important inputs.

This phenomenon of clustering of innovation as measured by patents was first observed by Jaffe et al., (1993), who found that patents will cite other patents originating in the same location more frequently than patents outside the location controlling for the existing geography of related research activity. Almeida and Kogut (1997) obtained similar results in studying patents in the semiconductor industry, confirming that patent citations are localized.[4]

In their studies of geographical proximity and the transmission of tacit scientific information, Zucker et al., (1998), and Audretsch and Stephan (1996) examined the proximity of biotechnology firms to scientists conducting research in the field of biotechnology. Zucker et al., found that the presence of star researchers in biotechnology in a region, as identified by a publishing record in genetic sequencing, was strongly and positively related to the number of biotechnology start-ups in a region. Accounting for other measures of regional intellectual capital such as the number of universities and the number of faculty receiving federal research support, they concluded that the growth and location of human intellectual capital as evidenced by star scientists were the main determinants of the growth and location of the biotechnology industry.

Audretsch and Stephan dealt with this same issue although their data allowed them to focus their investigation on those scientists actually affiliated with particular biotechnology start-up firms. Basing their data on all biotechnology firms that prepared an IPO in the early 1990s, Audretsch and Stephan found that while proximity does play a role in establishing ties between firms and their affiliated scientists, this influence is not overwhelming. However, when the particular roles of the scientists were examined the importance of proximity became clear. Scientists who were founders or were chair of a firm's Scientific Advisory Board (SAB) were much more likely to be locally linked to the firm than other affiliated scientists were. This result, although, cannot be extended to other scientists who were members of a firm's SAB only. From this they conclude that the tacit nature of knowledge in biotechnology means that knowledge transfer is best facilitated by face-to-face contact, and therefore geographical proximity. Firm founders and chairs of SABs are most involved in this knowledge transfer and so their proximity to the new firm is to be expected. Members of an SAB, on the other hand, do not need to be as close. Their explanation is that these members fulfill the role of signaling quality of the firm to the markets and advising the firm by charting its scientific direction. Such functions can be performed at a distance.

It should be noted here that biotechnology has been more frequently the subject of study in this area than other industries, because of both an inherent interest in this innovative industry and the availability of carefully collected data. As Martin and Scott (2000) observe, innovation in biotechnology occurs primarily through the commercial application by private firms of basic research conducted by universities and other research institutions. This is quite different from the mode of innovation that occurs in semiconductors and many other industries, and suggests caution in generalizing from biotechnology to other industries.[5]

Of course networks are conduits of more than just tacit technological knowledge. Within a

cluster networks dedicated to the creation and transmission of tacit, specialized market information exist as well. An exploration of the implications of proximity among these network actors has been extended to the spatial relationship between firms and their venture capital (VC) investors (Gompers and Lerner, 1999; Sorenson and Stuart, 2001; Powell et al., 2002).

Gompers and Lerner (1999), in a study of VC oversight of firms, examined the geographical proximity of 271 biotechnology firms between 1978 and 1989 and the venture capitalists that funded them. It was found that the proximity of the venture capitalist to the firm was highly significant in explaining their service on the board of directors even after the venture capitalist firm's ownership and age were accounted for. Because effective oversight of a firm by a venture capitalist requires frequent visits and close involvement in the firm's affairs, the costs of oversight are highly dependent on the distance between the venture capitalist and the firm.

Powell et al., (2002) found a strong pattern of spatial co-location of biotechnology firms and VC. Those VC firms that did invest outside their region tended to be older and larger. In their comprehensive study of VC investment across all industries from 1986 to 1998, Sorenson and Stuart (2001) observed that venture capitalists were more likely to invest in geographically distant firms when they had prior investing experience with other members of the investment syndicate. In general, VC firms that have established numerous relationships with other VC firms tend to invest more across geographic distance than do those firms that have not established such relationships.

2.2. *The constituent actors of an entrepreneurial support network*

One of the principal advantages of choosing to locate a new firm in a cluster is to access the specialized capabilities and knowledge that are to be found there. But as Powell et al., (2002) argue, the existence of an infrastructure within a cluster that fosters knowledge transfer and the provision of capital is an important element in the firm's decision as well. This infrastructure, or support network, is comprised of universities, law firms, research institutes, venture capitalists, and other professionals. This entrepreneurial support network maintains channels of communication among market participants that not only support the public good nature of technological and commercial knowledge, these channels also reduce the transaction costs of comprehending and utilizing such information (Antonelli, 2000).

In capitalist economies, quite naturally, access to capital is a requirement. In this study, two financial intermediaries, the venture capitalists and investment bankers, are included. The role of spatial and network proximity for financial intermediaries has attracted significant attention recently. Agnes (2002) in a study of the interest rate swaps industry found that 'different financial services have differing informational contents, with implications for the local embeddedness of financial services firms.' This is confirmed by the finding that formal institutional networks are actually embedded in informal relationships through which transactions and information flows (Thrift and Leyshon, 1994; Pryke and Lee, 1995; Clark and O'Connor, 1997). In other words, as Uzzi (1999) illustrates, formal relationships such as the lender–borrower relationship are embedded in a social context, and this social embeddedness, what Garud and Jain (1996) in their study of technological change refer to as 'just-embedded,' actually reduces the cost of loans and reduces risk. Abolafia (1997) finds that the necessity of social and physical proximity differs by the nature of the financial product. So, for highly standardized products such as listed equities and government bonds, traders need not be proximate, whereas for other more idiosyncratic financial instruments proximity is of greater importance.

As financial intermediaries venture capitalists act as a conduit between the supply of and the demand for investment funds. As is the case with all intermediaries they bring to the market an informed capability to assess the value and likelihood of success of potential investments, and the ability to secure funds from those willing to invest but lacking such investment knowledge. There is an ample literature suggesting that VC investing is a locally embedded practice, because of the importance of their monitoring and informal assistance functions that go beyond simply providing capital (Florida and Kenney, 1988; Gilson and Black, 1998; Sorenson and Stuart, 2001). Indeed, Greenwald and Stiglitz (1992) have observed that the VC industry shares many aspects with early financial market communities. Because VC firms operate in a 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. The critical venture capitalists in a start-up are what are termed the 'lead' venture capitalists who are the board members and those most responsible for monitoring and assisting the firm (Gompers and Lerner, 1999), and it is these venture capitalists that one would expect to be local.

Investment banks (IBs) are another part of a firm's entrepreneurial support network. Their expertise and connections with venture capitalists and entrepreneurs are core assets, from which other specialties have arisen. Here we would hypothesize that repeated transactions take place between individual venture capitalists and investment bankers, and that they will be located in close physical proximity to each other despite the fact that many of the IBs such as Goldman Sachs and Morgan Stanley are located on the East Coast. Historically, there were a number of smaller boutique IBs on the West Coast, including Hambrecht and Quist and Robertson Stephens, but they were acquired by larger banks during the 1990s. IBs provide young firms with connections and advice on raising capital. In the case of IPOs, they organize meetings with institutional investors and mobilize national networks of brokers willing to sell the firms' stock in an IPO. To develop the trust between the investment bankers and the firm, proximity in geographical and cultural terms should be important.

The legal profession is, quite naturally, local in practice even though most large legal firms have numerous branch offices. High-technology lawyers for small start-ups often have a multifaceted role that extends far beyond merely providing the legal services such as incorporation documents, etc. The management of intellectual property issues is of particular importance since so much of a high-technology start-up's value resides in IP, and IP constitutes most of its residual value in the event the firm fails. In entrepreneurial clusters such as Silicon Valley, these law firms do not emphasize litigation as much as they do advising entrepreneurs on the legal and business aspects of forming a firm, managing intellectual property especially in cases in which an entrepreneur is resigning from an existing firm, hiring key employees, and negotiating with investors. In short, these law firms operate as counselors to start-ups (Suchman, 2000).

Non-venture capitalist directors are a diverse group of individuals selected to provide direction and oversight for the new firm. These directors may fulfill a variety of different roles for the firm, including signaling to the larger financial community the validity of the new firm based upon their reputation. They may also be required to take on an advisory capacity with regard to specific technical knowledge they possess, or business acumen they have developed from prior experience. Non-venture capitalist directors are a polyglot group including corporate executives, university professors, former corporate executives, lawyers, and other professionals.

3. Context and background: Silicon Valley and the semiconductor industry

The geography of entrepreneurial networks in the merchant semiconductor industry is intimately related with the history of Silicon Valley. The pre-eminence 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, p. 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. The localization of the semiconductor industry in Silicon Valley is intimately related and strongly, although not solely, responsible for the growth of VC in the region.[6]

In a very real sense the semiconductor industry provided the foundation upon which Silicon Valley was built. Although numerous high-technology firms were established in Silicon Valley prior to the invention of the integrated circuit, semiconductors became the first discernable industry cluster in the region.[7] The evolution of the semiconductor industrial cluster in the region gave rise to all of the essential features that make up this remarkably innovative region.

Silicon Valley hosts a set of interdependent institutions that observers have termed an 'ecosystem,' a 'social structure of innovation,' or an 'incubator region' (Schoonhoven and Eisenhardt, 1989; Florida and Kenney, 1990; Bahrami and Evans, 2000). Silicon Valley can be considered as

two intertwined but analytically separable economies. The first set of organizations consist of established firms, corporate research laboratories, and universities that are the constituents of the existing economy that are in one form or another not unusual for any industrial cluster. Silicon Valley, however, has another set of organizations that combine to create an 'economy' predicated on facilitating entrepreneurs in the creation of new firms. Kenney and von Burg (2000) argue that this other economy is the *differentia specifica* of high-technology regions such as Silicon Valley, and is the trait that sets them apart from most other regions of industrial clustering.

The organizations of the first economy, either because of their charter to do research as in the case of universities and R&D laboratories, or as a by-product of their normal activities as in the case of firms, create inventions and innovations that may be capable of being capitalized in an independent firm. This ability to extrude an innovation from an existing firm is facilitated by the rapid pace in high-tech industry, which often creates technological discontinuities and accompanying economic opportunities. In the electronics industry, there have been recurring discontinuities, and very often the existing firms are unwilling or unable to exploit them, or simply miss them because they are preoccupied with their current businesses and customers (Christensen, 1997).

The organizations of the second economy comprise the institutional infrastructure that has evolved to enable the creation and growth of new firms (Florida and Kenney, 1988; Schoonhoven and Eisenhardt, 1989; Todtling, 1994; Bahrami and Evans, 1995). Just as computers and microprocessors are the actual products of the firms found in the first economy, new firms can be seen as the products of the institutional infrastructure of the second economy dedicated to the creation of new firms. We refer to the particular constituents within this infrastructure that a start-up wishing to go public must turn to as the firm's entrepreneurial support network.

It is this entrepreneurial support network that is the focus of this study. The preceding review of the literature on clustering and support networks allows us to suggest a number of stylized facts about the geography of the constituent actors of this support network in the semiconductor industry that can assume the form of hypotheses for this study.

As has been frequently noted, VC investing is a locally embedded practice. Because venture capitalists provide valuable assistance to start-up firms, as well as monitor their performance on behalf of the VC fund's investors, close geographical proximity is desirable. This role of advisor and monitor is particularly critical for lead venture capitalists that serve on the board of directors. Given the importance of this role for venture capitalist directors, we would expect that these directors would exhibit a greater geographical proximity to their firms than would directors not representing a VC firm.

The second financial intermediary that comprises a firm's entrepreneurial support network is the IB. Although investment banking is more geographically concentrated than other network actors, located primarily in New York, Boston, and Silicon Valley, it too is a locally embedded practice. We would therefore expect that start-ups within Silicon Valley would be serviced by local IBs, while start-ups outside of Silicon Valley would be serviced by New York and Massachusetts. In addition, because the connections IBs have with venture capitalists are part of their core assets in managing an IPO, we would expect that these financial intermediaries would be collocated, and that venture capitalists and IBs collaborating on the same IPO would be geographically proximate.

The legal profession is of course local in practice and is the most widely geographically available service of all those provided by the members of the firm's support network. The services provided by a firm's legal counsel can extend far beyond just legal services and involve business advising as well. Given the geographical availability of legal services together with the desirability of proximity, we would expect that there would be a close proximity between firms and their legal counsel within well-established industrial clusters where sophisticated legal business services can be found. For more remote locations, it is not clear whether the value of proximity would outweigh the need for experienced legal counsel.

Non-venture capitalist directors fulfill a variety of roles for the new firm. Directors appointed because of their technical knowledge or business acumen acquired from experience in the industry will tend to be locally embedded. Directors appointed because of their reputation so as to signal to the larger financial community the viability of the new firm, on the other hand, can fulfill this role at a distance. As noted above, we would expect that non-venture capitalist directors, because of their diverse roles, would as a group be

less geographically proximate than lead venture capitalist directors. In addition, because of the variety of their roles they fulfill, we would expect that non-venture capitalists will be more geographically dispersed than other network actors.

4. Data and methodology

Every firm wishing to go public must file a prospectus with the US SEC prior to its initial offering of stock. This IPO is a defining event in the history of any firm. The IPO performs two important functions: first, it provides the firm with capital so that it can continue its expansion. Second, after the IPO, the stakes of both management and investors (subject to certain lock-up delays) become liquid. In return, however, the firm must conform to the reporting and transparency requirements imposed by the SEC under the Securities Act of 1933. One of the primary objectives of the Securities Act of 1933 is to require companies making a public offering of their securities to publicly disclose relevant business and financial information about their company so that potential investors can make an informed investment decision regarding the offering. To achieve this end, the 1933 Act requires companies going public to file disclosure documents with the SEC, the most important of which are the general form S-1 registration statement and the 424B prospectus. These documents, in effect, provide us with a detailed snapshot of the firm at the time it goes public, and it is these documents that provide the basis of the data used in this study.

The semiconductor firms selected for this study were obtained from the Venture Economics database listing IPOs over the time period of June 1996 through the year 2000. These firms were identified by their Standard Industry Code (SIC) and were restricted to those filing an S-1 registration statement.[8] A population of 44 firms were selected by this criterion.

Although the IPO prospectus of a firm contains a great deal of information about the company going public regarding its finances, management, ownership, business strategy and the like, we have initially restricted our attention to the geographical location of the actors associated with the IPO.

On the lead page of every S-1 registration statement the names and addresses of the lawyers and their law firms involved in the IPO are given. In almost every instance the lawyers of two law firms are provided: one law firm representing the issuer, or firm going public, and one law firm representing the underwriters, or lead investment banker, of the IPO.[9] The addresses of these law firms allow us to map the precise location of two actors in the IPO process: firm lawyers and IB lawyers.

The location of the firm's lawyer has a straightforward meaning. The location of the IBs lawyer is less so. Originally, we had hoped to obtain the name of the lead investment banker, but when this was found to be infeasible we considered identifying the lead banker's location by selecting the IBs branch office having the closest proximity to the firm going public. This approach has a difficulty. If one simply attributes the investment to the local IB office, then one is guaranteeing close proximity. Therefore we rely upon the location of the IBs law firm as a proxy for the lead IB location. This choice was confirmed superior by anecdotal conversations with venture capitalists and investment bankers. The lead IB is identified in the prospectus as the underwriter having agreed to purchase from the firm, or issuer, the largest number of shares of stock for the IPO.

The SEC requires that each firm include a discussion of its management in its prospectus. This section on management includes a table that provides the name, age, and title of the executive officers and directors of the firm or other key employees. In addition, a one-paragraph biography of each individual in the table is provided, which indicates the individual's current and previous employment status and affiliation. On the basis of this information, we constructed a list of independent directors in the sense that they were not employed by the firm at the time of the IPO.

This group of independent directors was in turn broken into two mutually exclusive sets: those board members who were affiliated with a VC firm, and the remaining board members who were not so affiliated. Determining whether a board member was affiliated with a venture capitalist firm was based on their biography. The address and location of nearly all directors were found through extensive searching on the Internet. The addresses of these directors allow us to map the precise location of two additional actors in the IPO process: non-VC directors and VC directors.

5. Results and analysis

5.1. Geographical distribution of actors

For the 44 semiconductor firms in this population we found a precise location for all 88 law firms

Table 1. Distribution of semiconductor IPO actors by state.

State	Firms	Firm lawyers	IB lawyers	Non-VC directors	VC directors	Total actors
Arizona				1		1
N. California	27	30	31	52	40	180
S. California	5	3	4	9	3	24
Colorado	1		2	1		4
Connecticut				1	2	3
Delaware	1			1		2
Florida				2		2
Illinois					1	1
Massachusetts	2	2	4	4	10	22
Maryland					1	1
Michigan		1		3		4
North Carolina				1		1
New Hampshire					1	1
New Jersey	2			2		4
Nevada				2		2
New York	1	4	3	5	5	18
Oklahoma				1		1
Oregon	2	2		4		8
Pennsylvania	1			3		4
Texas	2	2		2	9	15
Virginia				2		2
Washington					1	1
National Total	44	44	44	96	73	257
Foreign	0	0	0	12	9	21
Not located	0	0	0	5	1	6
Total	44	44	44	113	83	284

IB, investment bank; VC, venture capital.

involved with the IPO. Of the 196 independent directors in this population we found a precise location for 160, and a general location within a state or country for another 30 of them leaving only six directors' location unknown. The distribution of these actors is shown in Table 1.

The most obvious feature of Table 1 is the dominance of California in firms that have gone public and the other actors in the start-up process. Massachusetts, New York, and Texas are of secondary importance while Oregon is of some importance as well. The dominance of California comes of course from the Silicon Valley, but Southern California as a region is of importance on its own. The relative importance of these regions and states can be seen in Diagrams 1A and 1B.

Diagram 1A shows the contribution of six regions: Silicon Valley (including the San Francisco Bay area), Southern California (LA and San Diego), Massachusetts, New York, Oregon, and Texas, to the ranks of the different actors. Diagrams 1B illustrates these same data by showing the contribution of the different actors to each of six regions plus all other.

These diagrams show that while the Silicon Valley dominates in these IPOs, Southern California, Massachusetts, and New York have all the

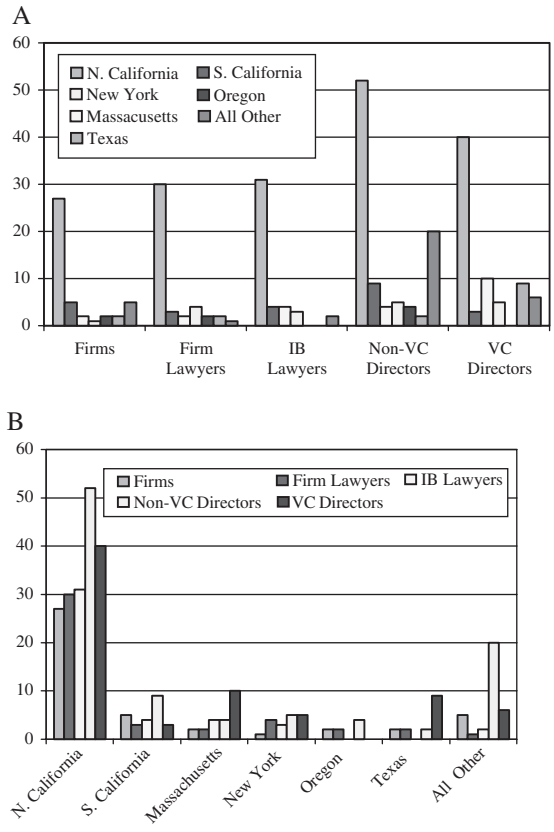

Diagram 1. Relative importance of regions and states. IB, investment bank; VC, venture capital.

actors required for facilitating IPOs. The importance of Boston for VC firms and the importance of corporate banking in New York City stand out, as does the presence of venture capitalists in Dallas and Austin, Texas.

5.2. *Spatial proximity of actors*

The proximity of these actors to the firm going public in addition to their distribution over regions is of interest. The histograms in Diagrams 2A and 2B for firm lawyers and IB lawyers, and Diagrams 3A and 3B for non-VC and VC directors show their proximity to a firm in straight line miles for those actors we have precisely located.

In comparing the proximity of law firms it is interesting to see how similar are the proximity distributions of firm lawyers and IB lawyers. In addition, the number of law firms precisely located having a proximity of 25 miles or less is 30 out of 44 for firm lawyers, and 23 out of 44 for IBs.

In comparing directors, proximity differs somewhat, with non-VC directors having a tendency to be either very close or on the other side of the country. This bicoastal pattern also emerges for VC directors. The proximity of these directors does not differ much although, with 52.3% of all non-VC directors being within 25 miles of the firm compared with 55.6% for VC directors.

The significance of the proximity of these actors can be seen more clearly by including all of the actors that can be located by state or country. We define an actor as being inside a firm's region if it is within 50 miles of the firm, and outside the region otherwise, including foreign actors who would obviously be outside the region. Table 2 shows this breakdown by category of actor.

The results found in Table 2 are consistent with the above discussion of proximity. A χ^2 test indicates that a firm lawyer is not significantly more likely to be located inside a firm's region than is an investment banker as located by the IBs lawyer, nor is there a statistically significant difference between the proximity of non-VC and VC directors. However, taken as a group it is true at the 0.001 level of significance that lawyers as a group are more likely to be within the region of a company than are directors as a group.

Because lawyers are so intimately involved in the negotiations surrounding the IPO and act as intermediaries among the actors it is not surprising that they should require close proximity to the

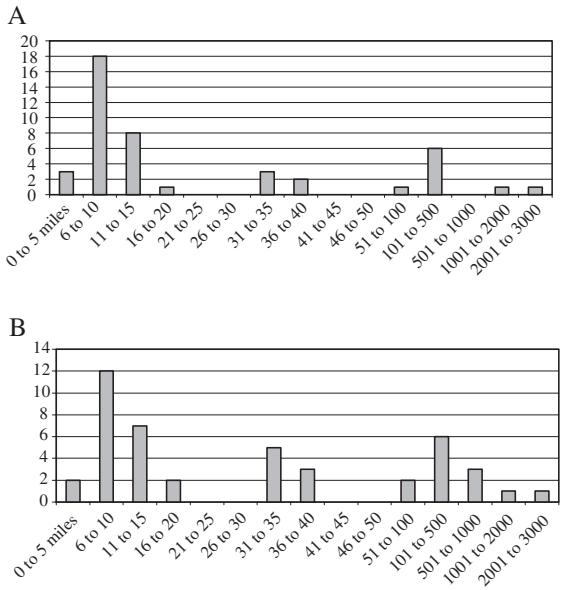

Diagram 2. (A) Firm Lawyers; (B) Investment Banks (IB Lawyers).

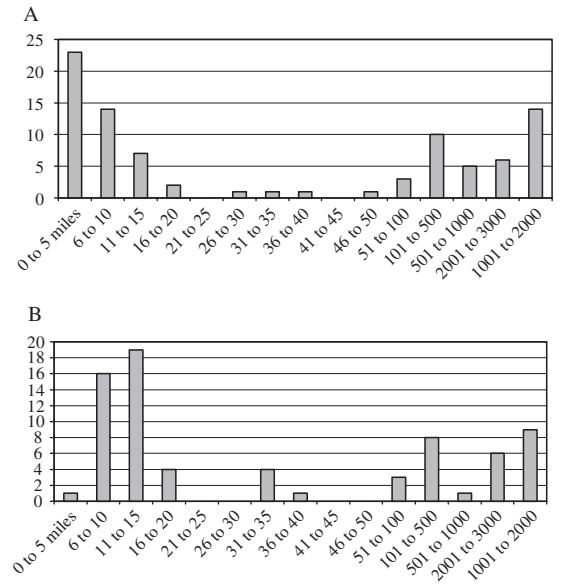

Diagram 3. (A) Non-venture capital (VC) Directors; (B) VC Directors.

firm during the IPO process. We would have hypothesized, although, that VC directors would in general have greater proximity than non-VC directors, in agreement with the results of Gompers and Lerner (1999) on VC oversight. Since Silicon Valley dominates this industry segment this result could be driven to some degree by the geographical distribution of these two types of directors and the firms they serve in the Valley.

Table 2. Proximity of IPO actors to firms.

	Firm lawyers	IB lawyers	Lawyer total	Non-VC directors	VC directors	Director total	Lawyers and directors compared
Inside region (%)	79.55 (35)	70.45 (31)	75.00 (66)	50.93 (55)	54.88 (45)	52.63 (100)	59.71 (166)
Outside region (%)	20.45 (9)	29.55 (13)	25.00 (22)	49.07 (53)	45.12 (37)	47.37 (90)	40.29 (112)
Total	(44)	(44)	(88)	(108)	(82)	(190)	(278)
χ^2			0.97			0.29	12.51
Mean distance	128.43	201.00		572.27	494.04		
Median distance	11	19		16.5	15.5		

IPO, initial public offering; IB, investment bank; VC, venture capital.

5.3. Network proximity of actors

The distribution of all actors across the US shown in Map 1 indicates that semiconductor activity is concentrated in California and along the Northeast corridor with pockets of activity in Texas and Oregon. The relationship or dyad between each firm and a member of its support network is indicated by a line. At this level of detail it is difficult to discern much more information. The density of activity in various centers such as Boston, New York City, and particularly the Silicon Valley, cannot be clearly shown on this map. Moreover, the networks that exist within and among these regions are not shown.

However, the networks that exist among these actors and the firms they serve in the IPO process can be shown through regional diagrams illustrating the relationships between each firm and members of its support network. The firms and actors

Map 1. National distribution of semiconductor firms and their support networks.

in this study are found primarily in Silicon Valley and five other regions, and all of the dyad relationships between a firm and a member of its support network can be placed within this regional framework. Diagrams 4–7 illustrate these regional dyad relationships for each of the four members of a firm's support network. To read these dyad diagrams the number in each box indicates the number of regional firms using the services of local regional actors. Arrows indicate the number of individual services being exported between regions in the direction of the arrow. If all the dyads are contained in boxes, then all services are provided locally; the more the arrows, the more geographically diffuse the networks through which services are provided.

In the case of Diagrams 4 the 27 firms in northern California all have law firms within northern California; two law firms in northern California represent firms in southern California, and one northern California law firm represents a firm in New Jersey. Three out of five southern California firms have lawyers within southern California. One New York law firm represents the New York firm, while another three represent firms in Delaware, New Jersey, and Pennsylvania. Both Oregon firms are represented by lawyers within the state, as are both Texas firms and Massachusetts firms. Finally, the semiconductor firm going public in Colorado is represented by a Michigan law firm. The arrow in these diagrams always points towards the firm.

In Diagrams 4, 37 out of 44 start-up firm–law firm dyads, or 84.1%, are within one of the six major regions in the semiconductor industry. Northern California is home to 27 out of 44 start-ups, and all 27 are serviced by local law firms. Given the importance of Silicon Valley as a center of specialized law firms experienced in the launching of new firms, this is to be expected. The other regions, although, also exhibit such proximity. The new firms serviced by New York are quite close, as are the two southern California firms serviced by Silicon Valley law offices. In fact, there are only two long-distance relationships: a New Jersey firm receiving counsel from Silicon Valley and a Colorado firm receiving counsel from Michigan.

Investment bankers, whose location is estimated by the IB lawyers, is also a locally provided service as shown in Diagrams 5, but less so than the firm–firm lawyer relationship. Here 30 out of 44 dyads, 68.2%, are within one of the major regions. It is noteworthy that the semiconductor start-ups in Oregon and Texas relied on out-of-

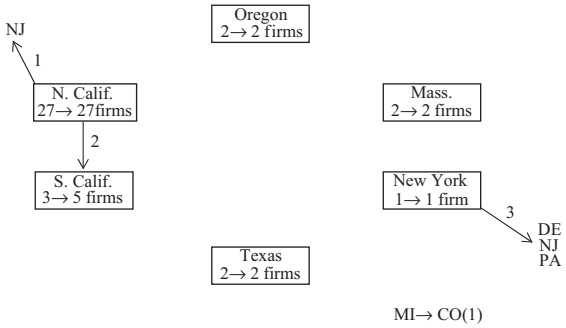

Diagram 4. Firm–firm lawyer dyads.

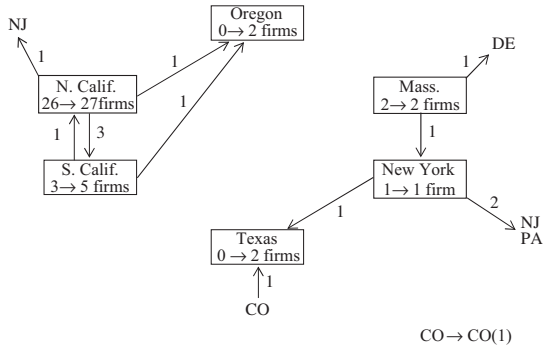

Diagram 5. Firm–investment bank lawyer dyads.

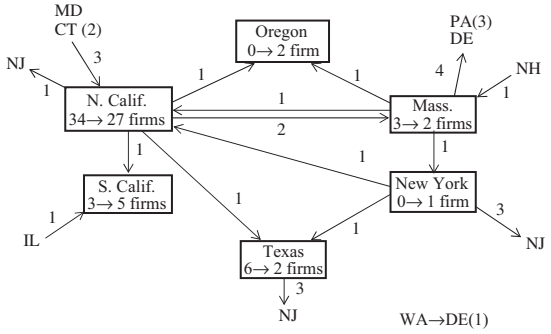

Diagram 6. Firm–venture capital director dyads.

state IBs while their legal counsel was sought locally. Again, Silicon Valley was nearly self sufficient in investment banking as in legal services.

The pattern of relationships between firms and the venture capitalists that sit on their boards of directors is more complicated as seen in Diagrams 6. Out of a total of 73 venture capitalist directors, 46 directors, or 63%, reside within the same region as the start-up board they serve on. Although there are more long-distance, bicoastal relationships between firms and their VC directors than there are between firms and their

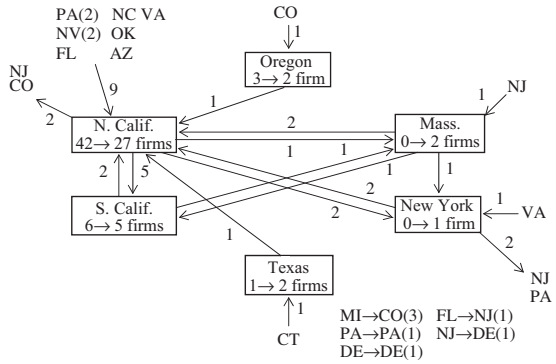

Diagram 7. Firm–Non- venture capital director dyads.

investment bankers, their regional proximity is not much less (63% compared with 68.2%).

Finally, we can see in Diagrams 7 that non-VC directors are the most geographically dispersed of the members of a firm's entrepreneurial support network. Of the six major regions, only 53 out of 96, or 55.2%, non-VC directors are located in the same region as the firm they serve. Moreover, non-VC directors are much more likely to be found outside of the six major regions than are the other support network actors.

5.4. Findings

Based on our understanding of industrial clusters, Silicon Valley, and the role of entrepreneurial support networks, we described some stylized facts and hypotheses about the geography of the members of these support networks in the semiconductor industry in the Context and Background section above. The empirical results reported here allow us to evaluate these hypotheses and report our findings on these network actors.

The legal counsel provided to start-up firms is the most locally embedded of these actors as measured by geographical proximity. This finding is supported by both the proportions of law firms within 50 miles of their firm as shown in Table 2, and by the map of firm–firm lawyer dyads found in Diagrams 4. It was hypothesized that there would be a close proximity between firms and their legal counsel within regions where highly experienced legal business services could be found. This was indeed the case for all regions, not just those having well-developed legal services, suggesting that for legal counsel proximity is of even greater importance than specific expertise for start-up firms.

Investment banking was found to be the second most proximate member of a firm's support network by both the measure of geographical proximity found in Table 2 and the firm – IB dyad diagram. Silicon Valley, Massachusetts, and New York were net exporters of IB services as would be expected. It was also hypothesized that start-ups outside of these three centers of investment banking would rely upon on these three centers of investment banking for their services. This was found to be the case.

VC is a locally embedded practice, but not as much as might be expected. Although start-ups found in regions where VC is concentrated rely primarily on local VCs, this tendency is not overwhelming. Just under 55% of all VCs are within 50 miles of the firms in which they are invested, and as shown in the dyad diagram, there were many firm–VC bicoastal relationships between Silicon Valley and the East Coast. This suggests that venture capitalist experience as well as proximity are of importance to a start-up. In addition, Massachusetts and New York were net exporters of VC services, particularly for East Coast start-ups.

It was hypothesized that both financial intermediaries in the network, investment bankers and venture capitalists, would tend to be collocated in those instances where they collaborated on the same IPO. To test this, the regional locations of the 37 start-ups having one or more VCs on their board were determined, along with the location of their IB and the VC nearest the firm. In 24 out of these 37 cases the start-up relied on local VCs and IBs collocated in the same region, providing some support for this hypothesis.[10]

Non-venture capitalist directors are the least geographically proximate of the network actors, and are the most geographically diverse as well from inspection of Table 1. It was also hypothesized that because of their diverse roles, non-VC directors would be less geographically proximate than VC directors whose responsibility in monitoring and assisting the firm would require them to be close to the firm. The χ^2 results in Table 2, although, did not support this hypothesis.

6. Conclusion

Investigations of the spatial location of the multiple constituents of the start-up environment have been limited. These studies have focused upon the VC–firm relationship, and even these studies have suffered from a lack of ability to identify the key

venture capitalists. This study is the first step in an effort to overcome these shortcomings. This descriptive study confirms many of the results from the existing dyad-based literature; however, it also advances the literature by providing a more comprehensive view of the institutions that support entrepreneurship in the semiconductor industry.

The attraction of the Silicon Valley to start up semiconductor firms for all of the reasons cited in the literature on clustering was clearly in evidence, as over 60% of all semiconductor firms going public from 1996 to 2000 nationwide were located within this region. This is because of both history and the remarkable concentration of knowledge, individuals, and specialized labor in Silicon Valley that a new semiconductor firm would need to acquire in order to be successful. The degree of clustering within the Silicon Valley also extended to the actors involved in the start-up process. Sixty-eight percent of all firm legal counselors in the IPO process were found within Silicon Valley, as were 70% of all investment bankers. Silicon Valley was also home to 54% of all directors serving on the boards of these start-ups. In short, semiconductor start-ups characterize an industrial clustering where one region emerges as the dominant location.

A second, and less expected finding from this study, is the extent to which the different members of the entrepreneurial support network differ in proximity to the firms they assist. The measures of spatial proximity and network proximity both point to the same ranking of proximity among the actors, with firm legal counsel being the most proximate, followed by investment banking, venture capitalist directors, and then non-venture capitalist directors being the least proximate. The different proximity of these actors to the firms they assist provides some insight into the roles they play in the start-up process. Because law firms were the most geographically proximate, it is clear that legal counsel in the new firm formation process is the most locally embedded of the functions performed by members of the firm's support network.

Investment banking and VC are concentrated in the same regions of the country: Silicon Valley, Boston, and New York. Because Silicon Valley is also the center of the semiconductor industry a high collocation of start-up firms and VC and investment banking would be expected. Because we have been able to establish the precise relationship between each start-up and its source of investment capital and investment banking, it was shown that geographical proximity was of importance in these relationships as well, but not to the same degree.

There were really few long-distance relationships between a firm and its investment banker; yet, such long-distance relationships were not uncommon between a firm and their lead venture capitalists. This suggests that the advising and monitoring function of the lead venture capitalist can be carried out at a distance even though geographical closeness is probably desirable. The failure to find a statistically significant difference between the proximity of lead venture capitalist directors, and directors not associated with a VC firm also supports this conclusion.

These results also have implications on how policy makers design policies for clusters. Emphasis is usually placed on the role of seed capital in encouraging new ventures in a region, a role usually played by venture capitalists in the private sector. The results discussed here, although, suggest that perhaps more attention should be paid to the capacity of the local legal establishment. The close proximity maintained by almost all of the semiconductor startups to their legal counsel indicate that these are the most local of the support network actors. The advising and monitoring function of venture capitalists, along with the provision of seed capital, could perhaps be conducted at a distance by firms outside of the region. The counseling function of the startups law firm, by contrast, appears to be almost exclusively a locally provided service among semiconductor startups. If these findings were found to be applicable to industries beyond semiconductors, then this would suggest that local development agencies should pay more attention to developing local capacity in legal services in supporting the counseling role played by law firms specializing in new firm formation, particularly in intellectual property and investment legal issues.

There are limitations to a study of this type. In our case the population is limited to only those start-ups that have been sufficiently successful to undertake an IPO. In addition, the population is quite small at 44 firms and is restricted to just one industrial sector. These limitations mean that our results should be seen as more suggestive than definitive, and because this study is limited to semiconductors it remains to be seen empirically whether these results apply to other industries.

Another limitation is that our analysis is restricted to just a short time period, from mid-1996 to 2000. As Feldman (2001) has shown, the

formation of an industrial cluster is a dynamic and complex process. Studies that only look at a single time period, particularly in an industry such as semiconductors that has such a well-developed cluster as Silicon Valley, may incorrectly conclude that the observed conditions in the cluster are essential preconditions, when in fact they lag the development of the cluster. We argue elsewhere (Kenney and Patton, 2004) that the support network observed in Silicon Valley co-evolved with the rise of high-technology industry in the region. Clearly, the entrepreneur possessing an idea is the first and foremost requirement for a new firm, but the assistance these new firms receive from the institutions and individuals that make up their support network is a critical component as well. By examining the economic geography of these members of the entrepreneur's support network, this study provides an insight into their role in the new firm formation process.

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Notes

1. On social embeddedness, see Granovetter (1985). On the embeddedness of economic activity in a regional context, see Storper and Salais (1997).

2. Swann and Prevezer observe that biotechnology did originate near San Francisco in part because of the proximity of venture capitalists located in Silicon Valley (p. 1140). However, their analysis of computing and biotechnology clustering did not explicitly consider venture capital or other members of the entrepreneurial support network, but rather focused on the role of industry sector and science base employment in promoting firm clustering.
3. The nature of the interactive environment of Silicon Valley and other industrial clusters is multifaceted and complex. For some recent discussions of the strengths and weaknesses of the cluster concept, see Gordon and McCann (2000) and Martin and Sunley (2003).
4. In an examination of labor mobility patterns among semiconductor engineers, Angel (1991) found that these engineers moved around the US However, if they moved to Silicon Valley their mobility continued, but now their mobility was confined to the Silicon Valley.
5. Indeed, the SABs studied by Audretsch and Feldman (1996) appear to be unique to biotechnology as only one semiconductor firm going public mentioned a Scientific Advisory Board in their prospectus. Swann and Prevezer (1996) also note that biotechnology clustering is promoted by the presence of a science base, unlike clustering in the computing industry, suggesting that the avenue by which technological information is diffused differs across industries.
6. For a history of the development of the venture capital industry in the Silicon Valley region, see Kenney and von Burg (1999).
7. See Sturgeon (2000) for a history of Silicon Valley before it acquired its namesake based on the silicon semiconductor planar process, developed at Fairchild in 1960, that allowed for the mass production of integrated circuits.
8. This eliminates firms considered by the SEC to be small businesses that file an SB-2 registration statement rather than an S-1.
9. In the case of a spin-off both the new firm and the parent firm have legal representation.
10. Twenty-eight out of 37 (0.757) VCs, and 27 out of 37 (0.730) IBs, were within the same region as the firm relying on their services. If we assume that the likelihood of both the VC and the IB being in the same region is due solely to their proximity to the start-up, then the expected number of IPOs where the IB and VC are in the same region is $(0.757) \times (0.730) \times 37 \text{ firms} = 20.4 \text{ firms}$. The actual number of such firms is 24, providing some limited support for the hypothesis.

