VENTURE CAPITAL AND HIGH TECHNOLOGY ENTREPRENEURSHIP

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EXECUTIVE SUMMARY

Venture capital clearly plays an important role in high technology entrepreneurship. The purpose of this article is to explain the differences among various venture capital complexes focusing on where venture capital is important to innovation and entrepreneurship and conversely where it is not. We do so through an empirical and historical examination of the seven most important venture capital complexes: California (San Francisco/Silicon Valley), Massachusetts (Boston), New York, Illinois (Chicago), Texas, Connecticut, and Minnesota (Minneapolis).

We establish a three-part tripartite typology for explaining the differences between these venture capital complexes: 1) technology-oriented complexes are located close to concentrations of high technology intensive businesses, invest most of their funds locally, and are net attractors of capital; 2) finance-oriented complexes are located around financial institutions and export their capital; and 3) hybrid complexes mix characteristics of both technology and finance-oriented venturing.

Our findings have a series of important practical implications. Although venture capital is not absolutely necessary to facilitate high technology entepreneurship, well-developed venture capital networks provide tremendous incentives for entrepreneurship by lowering the difficulties of entering an industry. Venture capitalists use both their experience and their contacts to reduce many of the information and opportunity costs associated with new business formation. The importance of contact networks and information to both deal flow and investment monitoring goes a low way toward explaining why venture capitalists cluster tightly together. The availability of venture capital also attracts entrepreneurs and high quality personnel to a region creating a virtuous circle of new enterprise formation, innovation, and economic development.

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Private, nonprofit, and subsidized public efforts aimed at providing venture capital and stimulating high technology entrepreneurship must confront the fact that venture capital alone will not magically generate entrepreneurship and economic development. It is important that such efforts recognize the nonfinancial side of venture investing and attract experienced personnel who can tap into established entrepreneurial networks and secure coinvestors. More significantly, establishing public venture funding in an area lacking the requisite entrepreneurial climate or technology infrastructure may create a "catch 22" situation where locally oriented funds invest in bad deals or where venture capital is simply exported to established high technology regions.

INTRODUCTION[1]

There is little doubt that venture capital plays a critical role in high technology entepreneurship and economic change. Clearly, the vibrance and rapid growth of California's Silicon Valley and Boston–Route 128 area owe much to the significant amounts of venture capital available there. The success stories of high flying start-ups like Fairchild, Intel, Digital Equipment Corporation (DEC), Apple Computer, Cray Computer, Sun Microsystems, Genentech, and countless others stand in sharp contrast to the stagnation and decline found in older manufacturing sectors. Thus, it is not surprising that both private and public sector actors have become enamored with venture capital as a mechanism for incubating technology businesses and generating economic growth.

Despite its importance in premier high technology regions, the availability of venture capital does not necessarily translate into high technology entrepreneurship. Two of the nation's foremost locations of venture capital, New York and Chicago, are quite laggard in terms of new business formation, innovation, and technology-based growth. These areas serve simply to collect venture capital which they then export to a variety of locations.

The way that venture capital complexes arise and how they effect high technology entrepreneurship are the major themes of this paper. We explore the origins and evolution of seven important venture capital complexes and suggest a three part typology for understanding them.[2] Technology-oriented complexes, such as San Francisco/Silicon Valley, are located around concentrations of technology intensive businesses, assume a local investment focus, and attract significant amounts of outside capital. Finance-based complexes, like New York and Chicago, are located in areas where financial institutions are highly concentrated, contain a high proportion of venture capital subsidiaries of financial corporations, and are export-oriented. Hybrids mix characteristics of both financial and technology-oriented venturing. This does not imply, however, that all hybrids are alike. Boston, Minneapolis, Texas,

[1]We would like to acknowledge the information and assistance provided by the following venture capitalists in the Midwest, northern California and Boston. David Morgenthaler and Charles James, who are headquartered in Cleveland and Columbus, Ohio respectively, gave us an invaluable assistance in launching our research. Venture capitalists we interviewed in northern California include: David Arscott, James Balderston, Frank Chambers, William Chandler, Thomas Davis, Wallace Davis, Reid Dennis, John Dougery, William Edwards, Mary Jane Elmore, Franklin Johnson, Eugene Kleiner, Burton McMurtry, Steve Merrill, Arthur Rock, Peter Roshko, Craig Taylor, Donald Valentine, David Wegmann, and Paul Wythes, as well as Henry Riggs of Stanford University. Those interviewed in Boston were: Peter Brooke, William Burgin, Richard Burnes, Craig Burr, Thomas Claflan, Daniel Gregory, Harry Heeler, Paul Hogan, Joseph Powell, Patrick Sansonetti, John Shane, and Courtney Whiten.

[2]Venture capital firms are financial intermediaries that collect capital from a variety of sources and redistribute it via their investments. The precise origin of the funds that are collected and deployed by venture capitalists is difficult to specify. While it is possible to examine the investors in venture capital partnerships, such as an endeavor is problematic since large financial corporations and other institutional investors mobilize funds in national and global markets. It is thus impossible to ascertain the precise origin of funds being supplied to venture capital firms. However, examining the distinct clusters or complexes of venture capital activity remains important since venture capitalists play a central role in collecting and mobilizing funds for high technology business formations.

and Connecticut can be better thought of as representing progressive points on a continuum running from predominantly technology-oriented to predominantly finance-based venturing.

Our research further suggests that coinvestment forms an important link between the various centers of venture capital activity. It allows venture capital firms located in export-oriented financial complexes to participate in deals originated by venture capitalists in technology-oriented complexes. Extensive coinvesting facilitates long distance flows of venture capital and reinforces the flow of venture capital toward locations that generate the best potential investment opportunities.

This paper presents findings from a firm level data base on the venture capital industry. The data base provides discrete information on venture capital investors, portfolio companies, and participants in investment syndications. It has been compiled from reports in *Venture Capital Journal* that focus on venture capital investments in various areas. Although the firm level data base does not comprise a fully representative sample of the venture capital industry, it enables us to approximate more accurately the investment and coinvestment patterns of the various complexes, and as such, allows us to understand better the evolution of leading complexes.

The remainder of this paper proceeds as follows. The first section summarizes our typology of leading venture capital centers. The following sections then explore their historical evolution. A summary of major findings is presented in the concluding section and their implications for both private and public sector practitioners are explored.

TYPOLOGY OF VENTURE CAPITAL COMPLEXES

Although venture capital activity has increased from approximately $3.5 billion in the 1970s to more than $20 billion today, investments are heavily concentrated in a few areas (Venture Economics 1983, 1985; Office of Technology Assessment 1984; Timmons et al. 1984; Florida and Kenney 1988a). Just two regions, the Northeast and West, account for the bulk of all venture capital resources, and within these regions, just three states—California, New York, and Massachusetts—control approximately 60% of the venture capital pool. Venture capital is tightly clustered in a few, distinct pockets across the United States.

Surprisingly, little research has been done on how venture capital evolves or why it clusters. The literature on venture capital gives only passing attention to these issues (Bean, Schiffel and Mogee 1975; Kozmetsky, Gill and Smilor 1985; Timmons et al. 1984). Although the most recent geography literature (Green and MacNaughton 1987; Leinbach and Amrhein 1987) makes note of such clustering, it provides little understanding of differences among various venture capital centers or of the implications of venture capital's geography for high technology entrepreneurship. The literature on technology innovation (Rothwell 1984; Rothwell 1985; Freeman 1984) and high technology regions (Dorfman 1983; Oakey 1984; Markusen, Hall and Glasmeier 1987) affords only cursory mention to the role played by different types of venture capital complexes in the formation of high technology regions.

Table 1 shows the differences that characterize the seven most important venture capital complexes in terms of our three-part typology. It presents data on the number of firms, total dollar volume of resources, and share of resources for California (Silicon Valley/San Francisco), New York, Massachusetts (Boston), Illinois (Chicago), Connecticut, Texas, and Minnesota (Minneapolis). Although the data arrayed in this table represent state-wide aggregates, the areas listed in parentheses comprise the predominant centers of venture capital activity. Venture capital complexes are generally identified under these titles in the following pages.

TABLE 1 A Typology of Leading Venture Capital Complexes

	Capital base (millions of dollars)	Number of Firms	Number of top firms[a]	Financial index	Financial-corporate index	In state/ outstate investment ratio
Financial complexes						
New York	3,262	95	17	1.05	1.26	0.32
	(20.0)[b]	(15.0)	(27.9)			
Illinois	863	23	4	1.00	1.00	0.09
(Chicago)	(5.3)	(3.6)	(6.6)			
Technology-Oriented Complexes						
California	5,296	173	13	0.59	0.64	2.20
(San Francisco/ Silicon Valley	(32.5)	(27.3)	(21.3)			
Hybrid Complexes						
Massachusetts	2,054	60	8	0.59	0.77	0.49
(Boston)	(12.6)	(9.5)	(13.1)			
Connecticut	794	21	2	1.00	1.63	0.14
	(4.9)	(3.3)	(3.3)			
Texas	775	54	4	1.00	1.13	1.14
	(4.8)	(8.5)	(6.6)			
Minnesota	380	15	2	0.50	0.50	0.78
(Minneapolis)	(2.3)	(2.4)	(3.3)			
Total	13,424	441	50	—	—	—
	(82.3)	(69.6)	(82.0)			
U.S. Total	16,308	634	61	—	—	—

Sources: Venture Economics (1985); *Venture Capital Journal;* Florida and Kenney (1988a).

[a]This is based on a grouping of the 61 most active venture capital firms as presented in Bygrave and Timmons (1986).
[b]Numbers in parentheses represent percentage share of U.S. total.

Three of the complexes are significantly larger than the others. California is the largest with $5.3 billion (32%) of the venture capital pool. New York is second with $3.2 billion (20%), and Boston has $2 billion (12%) of the venture capital pool. California also has the largest number of venture capital firms with 173, followed by New York with 95, and Boston with 60. Chicago, Connecticut, and Texas each control approximately $800 million in venture capital resources; Minneapolis controls roughly half that amount. Taken together, the seven venture capital complexes account for $13.2 billion (82.3%) in venture capital resources and 441 (70%) venture capital firms.

Our typology for the venture capital industry is supported by the following suggestive data. Four of the complexes are located in the only states that Glasmeier (1985) identifies as having high rankings on the absolute number of high technology jobs and on the ratio of high technology jobs to total manufacturing employment: California, Massachusetts, Connecticut, and Texas. The remaining two centers, New York and Chicago, are among the largest concentrations of financial resources in the United States, as well as Boston. The San Francisco Bay area also houses a significant concentration of financial assets.

The indices in Table 1 shed additional light on our typology. The financial index compares the number of venture capital subsidiaries of financial institutions to the number of limited partnerships, while the financial–corporate index adds venture capital subsidiaries of financial and industrial corporations together and compares them to the number of limited

partnerships. Index values of one suggest correspondence between categories; values below one indicate a preponderance of nonfinancial and/or nonindustrial venture capital partnerships, whereas values above one suggest the opposite. Venture capital subsidiaries of large corporations comprise a relatively large share of venture capital firms located in four complexes: New York, Chicago, Connecticut, and Texas. The three remaining centers, Silicon Valley/San Francisco, Boston, and Minneapolis, have larger relative concentrations of limited partnerships.

The ratio of in state to out of state investments provides an interesting snapshot into the investment patterns of the major complexes. According to these data, three complexes—New York (0.32), Chicago (0.09), and Connecticut (0.14)—are export oriented. Only two complexes, Silicon Valley/San Francisco (2.20) and Texas (1.14) favor in-state investments over exports. Two others, Minneapolis (0.78) and Boston (0.49), make a considerable but not overwhelming share of their investments in state.

Table 2 shows regional flow-of-funds data for the venture capital industry, providing better detail on the investment orientation of the various complexes. Before proceeding though, it is important to note two caveats concerning these data. First, the flow-of-funds data differ from the data on venture capital resources presented in Table 1. The latter include the total capital under management. In 1982, venture capital investments amounted to $1.8 billion or about one quarter of the total $7.6 billion under management. Second, because of the peculiar manner in which regions are demarcated in this data base, regional variables sometimes comprise reasonable proxies for state activity. For example, the West region includes California and two other smaller states, and the New York region includes just New York and the adjacent state of New Jersey. Problems arise, however, in areas such as the Midwest where Chicago, a key center of venture capital activity, is subsumed within a broad geographic area. The case of New England is even more problematic because Boston and Connecticut are combined as well as subsumed within a broadly defined region.

The ratio of venture capital receipts to investments presented at the bottom of Table 2 provides a rough guide to venture capital flows between the various complexes. According to these data, only California (2.25) and Texas (2.93) are net attractors of capital. The New England region, which includes both Boston and Connecticut, simultaneously attracts and exports capital, with imports and exports essentially balancing each other out. New York (0.49) and the Midwest (0.70), with its primary center in Chicago are enormous exporters of venture capital.

Taken together, the data shown above suggest a clear-cut investment pattern for venture capital complexes. The financial complexes, New York and Chicago, clearly favor exports. Silicon Valley/San Francisco not only retained the bulk of the venture capital it raised but also attracted substantial outside capital. Although there is some variation in investment flows for the hybrid complexes, each of these retained a sizeable share of the capital it generated and each was able to attract significant capital from outside sources.

The following sections deploy a variety of quantitative and qualitative historical material to document the unique characteristics of the various complexes. First, information generated from our venture capital data base is used to examine investment and coinvestment patterns and to identify links between complexes (Table 3). Second, the historical evolution of each complex is documented through detailed examinations of primary source documents, a thorough chronological review of the industry's trade publication *Venture Capital Journal* (hereafter abbreviated *VCJ*), reference to both published and unpublished secondary sources, and extensive oral interviews with leading venture capitalists.

TABLE 2 Venture Capital Flow of Funds, 1982 (millions of dollars)

Venture Capital Investments Received by Region	Venture Capital Investments Made by Region											
	New England	New York/ New Jersey	Midatlantic	South	Midwest	Texas/ Gulf Coast	Plains	Rockies	California/ Southwest	Pacific Northwest	Total Invested	Regional Share
New England	$93 32.9%[a]	$19 6.7%	$ 6 2.1%	$ 9 3.2%	$ 7 2.5%	$20 7.0%	$ 1 0.3%	$ 7 2.5%	$118 41.8%	$ 3 1.0%	$282 100%	15.5%
New York/ New Jersey	$61 17.0%	$66 18.6%	$15 4.2%	$11 3.1%	$15 4.2%	$31 8.7%	$ 3 0.8%	$14 3.9%	$136 38.3%	$ 3 0.8%	$355 100%	19.5%
Mid Atlantic	$ 5 8.1%	$ 2 3.2%	$ 4 6.5%	$ 2 3.2%	$ 1 1.6%	$ 3 4.8%	—[b] —	— —	$ 42 67.7%	$ 1 1.6%	$ 62 100%	3.4%
South	— —	— —	— —	$ 3 50.0%	— —	$ 2 33.3%	— —	$ 1 16.7%	— —	— —	$ 6 100%	0.3%
Midwest	$16 9.0%	$ 5 2.8%	$12 6.8%	$ 5 2.8%	$38 21.5%	$12 6.8%	$ 2 1.1%	$17 9.6%	$ 64 36.1%	$ 6 3.4%	$177 100%	9.7%
Texas/ Gulf Coast	$ 9 16.7%	— —	— —	$ 4 7.4%	$ 1 1.9%	$24 44.5%	— —	$ 5 9.3%	$ 7 13.0%	$ 1 1.9%	$ 54 100%	3.0%
Plains	— —	— —	— —	— —	$ 2 28.6%	$ 2 28.6%	$ 1 14.3%	$ 1 14.3%	$ 2 28.6%	— —	7 100%	0.4%

Rockies	—	$ 1	—	—	—	$ 1	$ 1	$ 3	$ 7	—	$ 13	0.7%
	—	7.7%	—	—	—	7.7%	7.7%	23.1%	53.8%	—	100%	
California/	$33	$ 7	$ 1	$ 2	$ 5	$22	—	$13	$280	$ 8	$371	20.4%
Southwest	8.9%	1.9%	0.3%	0.6%	1.3%	5.9%	—	3.5%	75.5%	2.1%	100%	
Pacific	—	—	—	—	—	—	—	$ 1	$ 8	$11	$ 19	1.0%
Northwest	—	—	—	—	—	—	—	5.3%	42.1%	57.7%	100%	
Foreign	$10	$11	$ 2	$ 4	$10	$ 3	—	$ 2	$ 36	$ 1	$ 78	4.3%
	12.8%	14.1%	2.6%	5.1%	12.8%	3.9%	—	2.6%	46.2%	1.3%	100%	
Unknown	$51	$61	$13	$22	$44	$38	$ 2	$19	$134	$14	$398	21.8%
	12.8%	15.3%	3.3%	5.5%	11.1%	9.6%	0.5%	4.8%	33.6%	3.5%	100%	
Total received	$278	$173	$52	$62	$124	$158	$10	$82	$833	$50	$1822	100%
Regional Share	15.3%	9.5%	2.9%	3.4%	6.8%	8.7%	0.5%	4.5%	45.7%	2.7%	100%	
Ratio of Receipts/ Investments	0.99	0.49	0.84	10.33	0.70	2.93	1.43	6.31	2.25	2.63	1.00	

Source: Office of Technology Assessment, *Technology, Innovation and Regional Economic Development* (Washington, D.C., 1984).

[a]Numbers expressed as percentages read horizontally as representing regional shares of venture capital investments made.
[b]Represents investments under $1 million.

TABLE 3 Investments and Coinvestments for Leading Venture Capital Complexes

	NY	MA	CT	CA	IL	MN	TX	Other/NA	Total
New York Complex									
Investments	31	8	4	32	5	0	8	40	128
	(24.2)	(6.3)	(3.1)	(25.0)	(3.9)	(0.0)	(6.3)	(31.3)	
Coinvestmens	59	23	5	77	19	7	5	56	251
	(23.5)	(9.2)	(2.0)	(30.7)	(7.5)	(2.8)	(2.0)	(22.3)	
Boston Complex									
Investments	6	37	0	26	0	2	5	36	112
	(5.4)	(33.1)	(0.0)	(23.2)	(0.0)	(1.8)	(4.5)	(32.1)	
Coinvestments	56	83	10	65	13	3	6	33	289
	(19.4)	(28.7)	(3.5)	(22.5)	(4.5)	(1.0)	(2.1)	(11.4)	
Connecticut Complex									
Investments	3	13	8	18	1	1	4	36	64
	(4.2)	(20.3)	(12.5)	(28.1)	(1.6)	(1.6)	(6.3)	(32.1)	
Coinvestments	67	35	19	49	5	1	9	83	268
	(25.0)	(13.1)	(7.1)	(18.3)	(1.9)	(0.4)	(3.3)	(30.2)	
California Complex									
Investments	1	17	1	142	1	4	11	29	206
	(0.5)	(8.3)	(0.5)	(68.5)	(0.5)	(1.9)	(5.3)	(14.1)	
Coinvestments	129	34	19	236	32	23	10	97	600
	(21.5)	(9.0)	(3.2)	(39.3)	(5.3)	(3.8)	(1.7)	(16.2)	
Chicago Complex									
Investments	1	1	1	9	3	3	6	14	38
	(2.6)	(2.6)	(2.6)	(23.7)	(7.9)	(7.9)	(15.8)	(36.8)	
Coinvestments	20	14	1	27	9	6	6	29	112
	(17.9)	(12.5)	(0.9)	(24.1)	(8.1)	(5.4)	(5.4)	(25.9)	
Minneapolis Complex									
Investments	0	2	0	5	2	21	1	17	48
	(0.0)	(4.2)	(0.0)	(10.4)	(4.2)	(43.8)	(2.1)	(35.4)	
Coinvestments	16	7	2	15	11	15	0	13	79
	(20.2)	(8.9)	(2.5)	(19.0)	(13.9)	(19.0)	(0.0)	(16.5)	
Texas Complex									
Investments	0	10	0	16	1	0	55	21	103
	(0.0)	(9.7)	(0.0)	(15.5)	(1.0)	(0.0)	(53.4)	(20.4)	
Coinvestments	27	39	12	55	8	8	59	93	301
	(9.0)	(13.0)	(4.0)	(18.3)	(2.7)	(2.7)	(19.6)	(30.9)	

Numbers in parentheses represent percentage share of total.

FINANCIAL COMPLEXES: NEW YORK AND CHICAGO

The New York and Chicago complexes are good models of finance-oriented complexes. Both are dominated by venture capital operations tied to major financial corporations or other institutional sources of wealth.

The New York venture capital complex emerged during the Great Depression. Its catalysts were venture capital funds linked to family fortunes, most notably the Rockefellers (Venrock), Whitneys (J.H. Whitney and Company), and Phipps (Bessemer Securities). The Rockefeller family made important venture investments in McDonnell Douglass and Eastern Airlines during the late 1930s, while J.H. Whitney and Co. provided backing for Minute Maid (*VCJ* November 1974, June 1979). In 1969, Venrock was set up as a formal venture

capital arm of the Rockefeller family. It has since provided early-stage financing for a host of important high technology companies, such as Intel and Apple Computer (*VCJ* June 1979).

More than 40 New York venture capital funds are linked to financial institutions, such as large commercial banks (i.e., Citicorp, Bankers Trust, and Irving Trust), or investment banks (i.e., Merrill Lynch; Drexel, Burnham, Lambert (Lambda); Smith Barney (First Century Partnership); and Donaldson, Lufkin, and Jenrette. New York City also houses a number of funds, like Rothschild and CMNY, which are affiliated with European investors (*VCJ* June, August, October 1979).

Most investments made by New York venture capitalists go to other regions. Only $66 million, or less than 20%, of the $355 million invested by New York venture capitalists was kept in state. Over $136 million (38%) was exported to California, $61 million (17%) was given to New England, and $31 million went (9%) to Texas. When inflows to New York from other regions are taken into account, venture capital invested in the area reached $173 million, barely half the total raised there.

The firm level data reinforce these findings. Barely one quarter of the 128 sample investments made by New York venture capitalists were located in state. Another 25% were located in California, with the next largest shares going to New England (9%), Texas (6.3%), and Illinois (3.9%). New York firms also had dispersed patterns of coinvesting, cooperating most frequently with California venture capitalists (30.7%), with one another (23.5%), and to a lesser degree with venture capitalists in Illinois and Massachusetts. To facilitate such long distance venturing, many venture capital firms in New York have opened remote branches in high technology regions like Silicon Valley and Boston–Route 128.

The Chicago complex is similar in many ways to New York. It is comprised of 23 venture capital firms that control about half of all venture capital raised in the Midwest. Allstate Insurance was very important to the rise of Chicago venture capital. In 1960, it became one of the first financial institutions to set up a venture capital fund (*VCJ* 1975). Allstate's director, Ned Heizer, made very successful investments in young high tech companies such as Control Data, Memorex, Scientific Data Systems, Teledyne, and others (Bylinsky 1976). In 1969, Heizer left Allstate to form his own venture capital company, which was the country's largest venture capital limited partnership when it was organized. Heizer Corporation became a training ground for venture capitalists and has in turn been responsible for spinning off a number of important venture capital companies.

Chicago banks became active in venture capital during the late 1960s and early 1970s. First National Bank of Chicago currently has two venture capital affiliates (First Capital Corporation of Chicago and the Institutional Venture Capital Fund), as does Continental Illinois (Continental Illinois Equity Corporation and Continental Illinois Venture Corporation). AMOCO and Sears have also made some significant venture capital commitments. The Chicago venture capital industry is rounded out by the important partnership, Golder Thoma, a number of smaller partnerships, and a few SBICs (*VCJ* August 1974, June 1981).

Like New York, the Chicago venture capital complex tends to export funds. This is reflected in the flow-of-funds data for the Midwest, which we use as a rough proxy for Chicago. Nearly 80% of the $177 million raised by the Midwest was exported, the most significant amount going to California ($64 million). The firm level data clarify this trend. Less than 10% of investments in our Chicago sample were located in Illinois. The largest share of investments (23.7%) went to California and Texas (15.8%). Because of their export orientation, Chicago venture capitalists coinvested frequently with venture capitalists located

elsewhere, particularly California (24%), New York (17.9%), and Boston (12.5%). Chicago venture firms invest frequently with other finance-oriented venture capitalists, especially those in New York.

SILICON VALLEY/SAN FRANCISCO AS A TECHNOLOGY-ORIENTED COMPLEX

The Silicon Valley/San Francisco venture capital complex is the best example of technology-oriented venturing. Venture groups began to emerge in the Bay Area during the late 1950s and early 1960s. Before then, entrepreneurs had to rely on industrial corporations or financial firms in more established financial centers for early-stage funding. For example, Shockley Transistor Corporation was started with backing from Beckman Industries, whereas financing for Fairchild Semiconductor was provided by Fairchild Camera.

The early venture groups in the Bay Area took on a variety of forms. The first venture capital firm in California, Draper, Gaither and Anderson, was founded in 1958 as a limited partnership. The following year saw the establishment of two federally leveraged SBICs, Continental Capital Corporation and Small Business Enterprises. Another SBIC, Draper and Johnson, was set up in 1962. The important firm, Sutter Hill, was founded as the venture capital arm of the real estate development firm. Bank of America and a number of other commercial banks also provided venture financing for expanding businesses during this early period.

In 1961, New York investment banker Arthur Rock formed a model limited partnership with Tommy Davis of Kern County Land Company. Of even greater significance was the revolving syndicate of independent investors centered around John Bryan and Bill Edwards, which later came to be known as "the group." One intermittent partner of "the group," Reid Dennis, was able to persuade his employer, Firemen's Fund Insurance, to invest in a number of new ventures.

The Bay Area venture capital industry thus emerged from a period of active experimentation with different types of organizations for providing venture capital. The seminal period, 1956–1963, witnessed the establishment of more than a dozen important venture capital firms in San Francisco and Silicon Valley. Faced with acute difficulties mobilizing funds and the need to share information and expertise, these early venture capitalists gradually evolved into an interactive community trading information and participating together in rudimentary coinvestments.

The late 1960s and early 1970s saw the dramatic growth and reorganization of the Silicon Valley venture complex. Much of this expansion came from the original group of venture capitalists. In 1968, for example, Bryan and Edwards was established, and George Quist, of Bank of America, set up Hambrecht and Quist. In 1974, Reid Dennis founded Institutional Venture Associates with Burton McMurtry of Palo Alto Investment. Two years later, Institutional Venture Associates split into two partnerships, McMurtry's Technology Venture Associates and Dennis' Institutional Venture Partners (Wilson 1985). Tommy Davis launched the important Mayfield Fund in 1974.

A variety of other actors entered the Silicon Valley venture industry during this period. In 1968, Bessemer Securities became one of the first East Coast venture capital firms to open a California branch. Eugene Kleiner of Fairchild Semiconductor was a cofounder of the important firm Kleiner Perkins in 1974, while Donald Valentine, an alumnus of both Fairchild and National Semiconductor, established Capital Management Services, Inc. (later Sequoia Capital) around the same time. Citicorp opened a West Coast office in 1973. A

host of new partnerships (i.e., Idanta Partners and WestVen Management) were formed during this period. Between 1968 and 1975, approximately 30 new or reconstituted venture capital operations were established in the Bay Area.

This period also saw an increase in outside funds committed to venture capital. One consequence was the emergence of the limited partnership—with professional venture capitalists managing capital provided by passive outside investors—as the dominant model for venture capital. University endowments, financial institutions, and pension funds initially bet on venture capitalists with proven track records. Over time, a growing group of former entrepreneurs, past employees of venture firms, and outside personnel were able to attract financial resources and launch limited partnerships.

The growth of Silicon Valley as an entrepreneurial center resulted in a shift in the locus of venture capital activity from San Francisco to Silicon Valley. The office complex located at 3000 Sand Hill Road, Menlo Park has been a virtual headquarters for venture capital activity since it was constructed in the early 1970s. Today, it houses more than two dozen venture capital firms, making it the largest single enclave of venture capital in the United States (Wilson 1985).

The Bay Area venture complex witnessed its most recent growth phase during the late 1970s and early 1980s. This period saw an even more dramatic surge in outside funding to the industry. The reduction in the tax rate on capital gains and the liberalization of restrictions on pension fund investments were two reasons for this (McMurtry 1986). The "profit squeeze" faced by many large corporations and the tremendous success of venture-backed start-ups such as Intel and Apple Computer also attracted external capital to the industry (Case 1986; Bygrave and Timmons 1986). This growing pool of funds encouraged significant spinoff activity from established funds. Citicorp, for example, became a virtual training ground for venture capitalists. Its alumni established a series of important partnerships during this period, notably Arscott, Norton and Associates (1978), and Dougery, Jones and Wilder (1981). Similarly, Merrill, Pickard, Anderson and Eyre was founded by members of Bank of America's venture group.

The early 1980s saw the emergence of venture capital "megafunds," as established venture capitalists pyramided partnership funds on top of one another. This resulted in a shift toward larger venture commitments and opened up an investment niche for seed funds concentrating on very early stage investments, i.e., Alpha Partners, Crosspoint Ventures, and Onset Partners (which was capitalized by a consortium of established venture capital funds). Finally, a host of venture capital firms headquartered elsewhere opened California offices, including L.F. Rothschild, J.H. Whitney, TA Associates, and General Electric Venture Capital (GEVENCO). Between 1978 and 1982, more than 50 venture capital funds were established in the Silicon Valley/San Francisco area (*VCJ* February, March 1980; January, March, November, December 1981; February, March, May 1982).

In sharp contrast to New York and Chicago, California is a tremendous attractor of venture capital. Three quarters ($280 million) of the $371 million it invested was placed in state. Just 25% was exported, most of it going to New England and Texas. California claimed nearly 50% of the capital invested by two regions, the Mid-Atlantic and Rockies, and approximately 40% of the investments of New England, New York, and the Pacific Northwest. Capital inflows of $136 million from the New York area and an additional $118 million from New England helped push the total amount of venture capital invested in California to $833 million, or more than 45% of the total pool. California ended up nearly tripling its endogenously raised resources as a result of such capital imports.

These findings are reinforced by the firm level data. Nearly 70% of the sample in-

vestments made by California venture capital firms were located in state. The next largest concentrations were found in Massachusetts (8%) and Texas (5%). California venture capitalists also liked to coinvest with one another. Same state coinvesting represented 39% of the deals in our California sample. California venture capitalists also participated fairly regularly in investment syndications with New York City firms (21%), and to a lesser extent with Massachusetts (9%), and Texas funds (5%).

Venture capital in the Silicon Valley area evolved gradually alongside the high technology enterprises that spring up there. Venture capital thus became an integral part of what we term a social structure of innovation (Florida and Kenney 1988): an interactive system comprised of technology intensive enterprises, highly skilled human capital, high caliber universities, substantial public/private research and development expenditures, specialized networks of suppliers, support services such as law firms and consultants, strong entrepreneurial networks, and informal mechanisms for information exchange and technology transfer.

The synergies among the various elements of this social structure created a unique window of opportunity for the emergence of technology-oriented investing apart from traditional financial institutions. The growth of technology venturing then proceeded along a learning curve characterized by the gradual accumulation of investment and management skills on the part of venture capitalists and entrepreneurs alike. This in turn facilitated the development of extended entrepreneurial networks that became conduits for sharing information, making deals, and mobilizing resources. As a central component of such networks, venture capital thus played an important role in incubating entrepreneurial activity, attracting entrepreneurs, and accelerating rates of new business formation.

BOSTON AS A TECHNOLOGY-ORIENTED HYBRID

The venture capital industry in Boston is a hybrid complex, combining characteristics of technology- and finance-based venture capital complexes. Boston was perhaps the first area to possess some degree of organized venture capital. As early as 1911, the Boston Chamber of Commerce was providing financial and technical assistance to new enterprises. In 1940, the New England Industrial Development Corporation was launched to provide similar kinds of assistance to new ventures (Kaplan 1948).

Boston was the home of American Research and Development (1946) the nation's first institutional venture fund. ARD was the creation of a prominent group of bankers and industrialists who saw such an entity as a way to more effectively finance technology-oriented enterprise (Liles 1977). In addition, a significant number of early venture capital investments in the Boston area were made by private individuals and wealthy families both from the Boston area and New York City.

By the early 1960s, large Boston financial institutions also became involved in venture capital. First National Bank of Boston established a program for providing loans to technology-oriented businesses and formed an SBIC affiliate. Around the same time, Federal Street SBIC was established, a consortium of Boston banks.

Like Silicon Valley, Boston witnessed the development of a technology-oriented venture community parallel to the emergence of the Route 128 entrepreneurial complex. ARD's enormously successful investment in Digital Equipment Corporation (DEC) in the late 1950s provided a vital impetus to the climate for high technology entrepreneurship in Boston. DEC played a significant role in the evolution of the Boston–Route 128 high technology center;

it became an incubator for more than 30 spinoffs, most notably Data General (Dorfman 1983).

ARD similarly became an incubator for venture capital funds. In 1963, Boston Capital Corp. was founded by ARD alumnus, Joseph Powell. By the 1970s, ARD alumni were instrumental in launching a host of top level partnerships including Palmer, Greylock, Charles River Partnership, and Morgan Holland (*VCJ* March 1974, August 1975, November 1976). In 1968, Peter Brooke left his position as manager of First National Bank of Boston's high technology loan program and later went on to launch TA Associates, which currently manages more than $1.5 billion in capital, making it the largest venture capital fund in the country.

As the technology base of the Boston region developed, a host of partnerships were organized by veteran venture capitalists. Both Burr, Egan and Deleage and Claflan Capital Management were formed by former TA Associates employees, while the Venture Capital Fund of New England was established by managers of First National Bank of Boston's venture group. The late 1970s and early 1980s also saw the formation of new funds, such as Eastech and Zerostage, and the movement of branch offices of funds headquartered elsewhere, such as Bessemer Venture Capital, to the Boston area.

Our interviews with Boston venture capitalists indicate that the Boston complex is not nearly as tightly organized as that of San Francisco/Silicon Valley. There appears to be much less information sharing and/or coinvesting among Boston venture capitalists, although a number of Boston firms possess rather tight links to New York City venture capitalists. In contrast to California, a significant number of Boston venture firms are involved in large-scale financial transactions such as leveraged buyouts (LBOs) which clearly fall outside traditional venture capital activities.

The data on investments and coinvestments illuminate the hybrid characteristics of the Boston complex. If we use data on the flow of funds for New England as a proxy, the Boston complex essentially breaks even when imports and exports are taken into account. Roughly one third ($93 million) of the $282 million invested by venture capitalists in New England was placed within the region. A sizeable percentage was exported, with the largest amounts going to California ($118 million), New York ($19 million), and Texas ($20 million). However, New England was able to replenish its capital exports with sizeable inflows from other areas. These included inflows of $61 million from New York, $33 million from California, and $16 million from the Midwest.

The firm level data clarify these trends. Boston venture capitalists concentrated approximately one third of their investments in state. More than 20% were made in California. Boston venture capitalists coinvested regularly with one another as well as with venture capitalists located in other complexes. Nearly 30% of investment syndications involving Boston venture capital firms were with other Boston firms, whereas 22% were with venture capitalists in California, and 19% were with New York firms. Even though Boston venture capitalists participate in a significant amount of long distance investing, the their venture capital complex remains an important component of the Boston–Route 128 high tech region and the broader social structure of innovation that characterizes that area.

DIFFERENCES AMONG HYBRID COMPLEXES: CONNECTICUT, TEXAS, AND MINNEAPOLIS

The three remaining complexes—Connecticut, Texas, and Minneapolis—all exhibit hybrid characteristics. The Connecticut venture capital industry got its impetus in the late 1960s.

During this formative period, a tightly knit group of wealthy families began to actively engage in venture capital investments. In 1969, Harlan Anderson, a founder of Digital Equipment Corporation (DEC), set up Anderson Investment Company. Another early venture capital operation was established by Sherman Fairchild, whose capital came from family investments in IBM. In 1972, Thomas Watson, a former Board Chairman of IBM, launched Partnership Dankist, which later came under the direction of Thomas Murphy (*VCJ* March 1976). Murphy went on to organize the Fairfield Venture Capital Group, an informal assemblage of 30 to 40 venture capitalists and independent investors.

Connecticut houses three of the largest venture capital subsidiaries of industrial corporations (Mears 1981; *VCJ* May 1982, May 1983, March 1984, March 1985). General Electric set up its venture capital operation GEVENCO in 1968. Xerox Venture Capital has been involved in venture investing since the mid 1970s, while Vista Ventures, the $100 million fund affiliated with SOHIO, was established in 1980.

Rounding out the Connecticut venture capital industry are a series of private partnerships founded in the early 1980s. These include Oxford Partners, Fairfield Venture Partners, Prime Capital, and Regional Financial Enterprises. Many of the principals of these partnerships served lengthy apprenticeships with the venture capital subsidiaries of corporations headquartered in Connecticut (*VCJ* May 1982). The largest venture capital firm in Connecticut is Oak Management with $240 million under management. It evolved out of the Charter Oak Enterprises, which was the primary consultant for Xerox's venture capital operation during the mid 1970s (*VCJ* March 1976).

The firm level data indicate that Connecticut venture capitalists make about one third of their investments in New England. Approximately 20% of their investments were in Massachusetts, with roughly 12% located in state. California accounted for 28% of the investments made by Connecticut venture capitalists. Connecticut venture capitalists coinvested regularly with venture capitalists headquartered on the East Coast. One quarter of their coinvestments were with New York firms, another 13% were with Massachusetts venture capitalists, and 17% were with one another. Connecticut venture capitalists also frequently engaged in investment syndication with California venture firms.

The Texas venture capital complex consists of four distinct subcenters: Dallas, Houston, San Antonio, and Austin. The largest center is Dallas with $285 million. Dallas has a number of major venture capital limited partnerships including Sevin and Rosen, Capital Southwest, Southwest Enterprise Associates, and Berry Cash. Dallas also has branch offices of funds headquartered elsewhere, most notably Citicorp (New York), Orange Nassau (Boston), Golder Thoma (Chicago), and Business Resource Investors (*VCJ* August 1980, June 1984).

The venture capital centers located in Houston, Austin, and San Antonio are roughly half the size of Dallas complex. San Antonio controls $86 million. Austin accounts for $62 million. Houston controls $66 million in venture capital, but its industry is dominated by small partnerships and SBICs who coinvest regularly with each other.

Venture capital in Texas has been heavily skewed toward energy-related investments. According to a recent study (Kozmetsky, Gill and Smilor 1985), Texas venture capitalists placed more than 70% of their funds in energy-related businesses. This raises questions as to the long-term viability of venture capital in Texas during a prolonged slump in energy prices.

The Texas complex was able to retain a significant share (45%) of the $54 million in venture capital it invested. Slightly more than half was exported, with the largest amounts going to New England ($9 million) and California ($7 million). Like California, the Texas

complex has been a net attractor of capital. Inflows of $31 million from New York, $22 million from California, $20 million from New England, and $12 million from the Midwest boosted investments in the region to $158 million—more than triple the amount that was raised there. Texas-based venture capital firms coinvest regularly one another (19.6%), with venture capitalists in California (18%), Boston (13%), and New York (9%).

Venture capital in Minneapolis represents a technology-oriented hybrid. The Minneapolis complex is distinguished by a small number of firms that are tightly networked and that invest heavily in the Minneapolis area. Minneapolis was an early site for both venture capital and high technology business. During the 1950s, it was the center for the Sperry Rand–UNIVAC, one of the early commercial computer projects. In 1957, Control Data Corporation, a very successful computer company, was organized as a spinoff from the UNIVAC project. Minneapolis was the site of the first licensed SBIC, First Midwest Capital Corporation in 1959 (Ruvelson 1971; Noone and Rubel 1970). The following year saw the establishment of Northwest Growth Fund, a subsidiary of Northwest Bancorporation, and Community Investment Enterprises, a private venture capital firm (*VCJ* June, July 1977).

Minneapolis continued its gradual evolution as both a venture capital and a high technology center through the 1970s. The establishment of Cray Computer made Minneapolis a leader in the supercomputing field. Control Data Corporation established an SBIC affiliate in 1974. Rounding out the Minneapolis complex are a series of private partnerships and SBICs, most notably Pathfinder Venture Capital Fund and North Star Ventures (*VCJ* October 1981).

As in Silicon Valley, the venture capital industry in Minneapolis evidences a local investment focus. More than 40% of investments made by Minneapolis firms were located in Minnesota. Minneapolis venture capitalists regularly coinvest together. Nearly 20% of the sample coinvestments involving Minneapolis firms were with other Minneapolis venture capitalists. Minneapolis firms not only participate in a wide range of syndicated investments in other states but also are able to attract significant amounts of outside capital, especially Chicago capital, to Minnesota. In a number of cases, Minneapolis venture capitalists have been able to put together investment syndications involving various combinations of top-level Chicago, New York, California, and Boston venture capitalists. Simply put, Minneapolis is the best example of a nascent entrepreneurial center which has the potential to develop into a full-fledged technology complex.

CONCLUSIONS AND IMPLICATIONS

Our examination of the venture capital industry leads to a number of relevant conclusions. First, there are significant differences among the major venture capital complexes. Not surprisingly, venture capital is concentrated in distinct types of areas: those with high concentrations of financial resources, those with high concentrations of technology-intensive small businesses, and those with both. Venture capital complexes based in financial centers like New York or Chicago contain relatively large proportions of venture capital subsidiaries of financial institutions and export their funds. Technology-oriented complexes, i.e., Silicon Valley/San Francisco, contain large proportions of limited partnerships, favor local invest and attract venture capital from other areas. Boston and Minneapolis are best characterized as technology-oriented hybrids, whereas Connecticut is a finance-based hybrid. Texas is to some extent unique because of its four distinct subcenters and its energy, versus technology, intensive focus.

Second, the high concentration of good deals in established technology centers creates

enormous incentives for venture capital firms to locate there. This results from the high opportunity costs associated with long distance venturing and the information intensive nature of venture investing, which makes tight spatial clustering of venture capitalists a virtual necessity. Indeed, strong, interpersonal networks form the heart of technology-oriented venture capital complexes like California's Silicon Valley. These function as vehicles for finding deals, locating personnel, organizing companies, or establishing investment syndicates. Geographic clustering of venture capitalists enhances their ability to share information, make deals, and mobilize resource over very short time horizons.

Third, the relationship between technology-oriented and finance-oriented venture capital complexes is a symbiotic one. Investment syndicates link export-oriented funds to venture capitalists located in the vicinity of established technology areas (Florida and Kenney 1988a). In most cases, funds in financial complexes function as passive investors, depending upon their counterparts in technology complexes to assume the role of lead investor and provide the bulk of assistance to portfolio companies. While such firms are "free-riders" on venture capitalists located in technology regions, they provide significant infusions of capital, allow technology-oriented venture capitalists to expand their investments, and increase the scope of venture capital activity.

Finally, even though a local venture capital industry or venture capital firm is not absolutely necessary to facilitate high technology entrepreneurship, the existence of well-developed venture capital networks provides tremendous incentives for start-ups. As focal points of the well-developed social structures of innovation that have emerged in areas like California's Silicon Valley and Boston's Route 128, venture capitalists function as both catalyst and capitalist—providing the networks, contacts, linkages, and resources necessary to launch new enterprises. The availability of venture capital and the existence of such networks helps attract entrepreneurs and technical personnel to these regions, creating a self-reinforcing cycle of new enterprise formation, innovation, and economic development.

These findings have important practical implications for both private and public efforts aimed at stimulating high technology entrepreneurship and local economic development. Many venture capitalists we have talked to perceive declining investment opportunities in established regions due largely to the increased availability of venture capital in these areas. This has motivated some venture investors to look elsewhere for deals at times through the vehicle of remote branch offices. Although there are few data to assess such investment strategies, they appear to confront numerous obstacles. The belief that venture capital alone will stimulate entrepreneurship in dormant areas and provide windfall profits for crafty investors who can identify hidden pockets of entrepreneurial activity seems dubious at best. We contend that venture capital is much more than money. A fruitful climate for innovation and entrepreneurship is dependent upon a host of interactions, networks, and linkages which characterize only certain areas and which venture capitalists in these areas have privileged access to.

This does not mean that Silicon Valley and Boston–Route 128 hold a monopoly position on high technology business formations. As our examination of Minneapolis shows, areas with concentrations of both high technology businesses and venture capital can be late developers. This also appears to be the case with parts of Florida, central New Jersey, the Pacific Northwest, and Colorado. It should be remembered, however, that the emergence of these complexes does not result from any specific recipe of factors. The incubation of high technology districts anchored by venture capital occurs organically, as a gradual process characterized by many unknowns and contingencies. Simply making venture capital available

will not magically generate the conditions under which high technology entrepreneurship can flourish.

These cautions apply doubly to public sector activities aimed at creating public equity funds to encourage high technology economic development. Recent years have seen a surge in state and local activity designed to overcome gaps in the availability of venture capital, incubate high technology, and create environments more conducive to new business formation. These include both the establishment of wholly public funds and the use of private venture capitalists to invest public money. The establishment of public equity funds is problematic since political imperatives may impede decisions best made on the basis of market and technological criteria. In addition, the expansion of public capital may simply mean another round of interlocality competition pitting jurisdiction against jurisdiction in another mad scramble for high tech businesses and jobs. More importantly, public funds must face up to the fact that financing is just a small part of what venture capitalists do. The success of new ventures is ultimately contingent on the support services that venture capitalists can provide or have access to.

An even thornier set of problems crops up when public funds are managed by private venture capitalists. This takes the form of a "catch 22." Placing tight strings on the geography of investment may so constrain deal flow that bad investments are made, causing the fund to perform poorly. If no strings are attached, investments are likely to flow toward Silicon Valley and Boston's Route 128, resulting in regional transfers of capital and further depletion of local resources. Whatever the case, it is clear that public participation in venture capital confronts many obstacles. In areas lacking the requisite set of supports to incubate high technology business formation these obstacles are often likely to be insurmountable.

Our examination of the various types of venture capital complexes leads to some unavoidable conclusions. Venture capital will not grow up everywhere, and even in those places where it emerges, venture capital is not necessarily sufficient to generate high technology entrepreneurship. Technology-oriented venture capital complexes and their hybrid variants are unique occurrences that grew up synergystically alongside both high technology businesses and a wide range of support mechanisms for innovation and entrepreneurship. No one factor can be isolated as causal; no series of contributing factors can be reproduced. Huge concentrations of venture capital in New York and Chicago have stimulated virtually nothing in the way of local high technology entrepreneurship. The inability of North Carolina's Research Triangle to generate a self-sustaining entrepreneurial environment or venture capital community stands as further witness to the difficulty of creating high technology complexes de novo.

The challenging research agenda and the one that must be addressed is not to simply isolate the component factors that established entrepreneurial regions possess, but to explain the way they interact to produce synergies and to further probe the historical processes that bring them together in the first place. This is what we have tried to do in our historical exploration of a variety venture capital complexes. We hope we have succeeded in debunking some of the more curious myths surrounding the role of venture capital in high technology entrepreneurship.

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