High-Tech Start-Ups and Industry Dynamics in Silicon Valley

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Foreword

The Bay Area economy is experiencing one of its most prolonged recessions: Unemployment continues to climb, start-ups in Silicon Valley have declined from over 3,500 a year in 1998 to well under 1,000 in recent years, and, nationwide, the high-tech sector appears to be facing a future of excess capacity. These are certainly sufficient reasons for the general mood of gloom that has settled over a region that was recently the focus of international attention for its high-tech successes. Why this dramatic turnaround in the economy of Silicon Valley? What are the prospects that the region will be booming once again?

High-Tech Start-Ups and Industry Dynamics in Silicon Valley by Junfu Zhang is yet another contribution by PPIC to an improved understanding of the California economy. This research project is one of a series that PPIC has launched to gain a better understanding of California's new economies and of the dynamic processes that underlie their cycles of boom and bust. Past PPIC studies have looked at the role of immigrant entrepreneurs and their linkage to Asia, the role of U.S. tariff policy and its effect on increasing export activity, and the role of exports and foreign direct investment in building California's economy for future decades.

Zhang's research concludes that, collectively, new firms represent a major force in the economic dynamics of Silicon Valley. For example, firms founded after 1990 created almost all of the job growth experienced by Silicon Valley between 1990 and 2001. Why, then, do we find ourselves in the midst of the current bust cycle? The theory most applicable to the current situation was developed by Joseph Schumpeter in 1911. In *The Theory of Economic Development*, he explained, "The economic system does not move along continually and smoothly. Countermovements, setbacks, incidents of the most various kinds occur, which obstruct the path of development; there are breakdowns in the economic value system which interrupt it." And, he argued, these setbacks

lead to the development of new ideas, new entrepreneurs rise to the occasion, and soon the cycle begins all over again. The cycle of firm start-ups, closures, and new start-ups is very much part of the economic development process, and the very entrepreneurs who are in abundant supply in Silicon Valley will make the process happen all over again.

For Silicon Valley, this cycle is as much fact as theory. In the 1950s, a handful of firms supplied electronic devices to the Defense Department. In the 1960s, the region became a center of computer chipmakers. In the 1970s and 1980s, the region developed and manufactured personal computers and workstations, and in the 1990s, the region helped commercialize Internet technology. For every major firm, such as the Hewlett-Packard Company and Intel, there were thousands of entrepreneurs starting little firms with dreams of one day becoming a leader in their field.

Zhang concludes that start-ups in Silicon Valley have more rapid access to venture capital than comparable firms elsewhere in the nation; that large, established firms spin off more start-ups than firms in other parts of the country; and that the high-tech sector is subject to rapid structural change where "hot spots" of growth may appear in some industries while firms in other industries are simultaneously dying out. He observes that a dynamic labor force has been, and will be, essential to successful adaptation with each new structural change. In sum, human capital, venture capital, entrepreneurial zeal, and product cycles all contribute to the health and success of the economy of Silicon Valley.

Although Zhang makes no predictions about the future, the fact that the region has weathered these cycles in the past, that the basic ingredients are still there in abundance, and that new demands for high-technology products are following on a worldwide concern for secure environments suggests that the prospects are good for yet another rebirth of the valley. Zhang suggests that the dynamics of economic development favor Silicon Valley and that yet another replay of the rebirth part of the cycle lies before us.

David W. Lyon
President and CEO
Public Policy Institute of California

Summary

After extraordinary economic success in the late 1990s, Silicon Valley entered a deep recession in 2001. Today, policymakers, academic researchers, and the general public continue to puzzle over what made Silicon Valley such an enormous success. More important, they wonder if the region will ever experience such strong growth again. This study seeks to answer those questions by examining Silicon Valley's high-tech economy in a dynamic context. Using two unique longitudinal databases, we investigate firm formation, growth, mortality, and migration in Silicon Valley during the 1990s and explain how the region's economy evolves and operates through such dynamic processes. This study not only helps us better understand Silicon Valley's success in the past but also reveals insights into how Silicon Valley can ensure its future prosperity.

Major Findings

New firms are important for Silicon Valley. As with other high-tech centers, Silicon Valley hosts a wide variety of firms. A multitude of small firms coexist with medium-sized and big firms; and each year, many new firms are founded, which collectively are a major driver of the economic dynamics in Silicon Valley. In fact, firms founded after 1990 created almost all the job growth during 1990–2001. Young start-ups in Silicon Valley consistently attract a large amount of venture capital. Successful start-ups have remade and will continue to remake Silicon Valley.

Start-ups in Silicon Valley have quick access to venture capital. On average, it takes 11.6 months for Silicon Valley's start-ups to complete their first round of venture finance, five months faster than the national average. In addition, the quicker access to capital is found in every major industry in Silicon Valley. This gives start-ups in the region a head start—an important advantage in high-tech industries that advance at a

very fast pace. This large first-mover's advantage implies that start-ups in the valley will have better chances to survive, all else being equal.

Established firms in Silicon Valley spin off more start-ups. Compared to their counterparts in the Boston area, big companies in Silicon Valley have more previous employees who start their own venture-backed businesses. Since engineers in successful firms are in the best position to grasp and commercialize cutting-edge innovations, a high rate of spin-off helps open new markets and creates new jobs. Previous research discusses Silicon Valley's high incidence of firm-level spin-off based on anecdotal evidence and has identified cultural and legal factors to account for it. Although the causal factors remain unclear, for the first time we have confirmed with empirical data that there are indeed more firm-level spin-offs in Silicon Valley than in other high-tech centers.

Firm relocation is not a serious problem. High-tech start-ups value the hotbed of innovation because that is where new ideas emerge and entrepreneurs cluster. Silicon Valley is a perfect environment for start-ups whose major objective is to develop innovative ideas. On the other hand, when firms become mature and enter the phase of mass production or routine services, their major concern becomes sustainability and they naturally care about operating costs. For those firms or, rather, for certain operations of those firms, Silicon Valley is unattractive. We have investigated whether firms leave Silicon Valley when they have evolved out of the start-up stage. We find that indeed more establishments move out of Silicon Valley than move in, and establishments moving out tend to be older. Establishments still tend to stay close to the valley when they move out. When firms move across state borders, Silicon Valley does see a net job loss, because more jobs are relocated to other states than are relocated to Silicon Valley from outside California. However, the data suggest that firm relocation involves a relatively small proportion of the labor force. Firm birth and death cause much more turbulence than firm relocation. In other words, once firms are established in Silicon Valley, they are very likely to remain there. Intensive entrepreneurial activities certainly compensate for the jobs lost through firm relocation.

Successful firms in the valley are branching out. Although relocation does not occur at significant levels, established firms in Silicon Valley frequently set up branches elsewhere. For many large high-tech companies headquartered in Silicon Valley, their employment within Silicon Valley itself is only a small proportion of their total employment. Since Silicon Valley is already tightly packed with thousands of firms, fast-growing start-ups are more likely to expand outside the immediate area. As firms begin to expand, they potentially benefit the rest of California by setting up branches elsewhere in the state.

The high-tech sector experiences rapid structural changes. The high-tech sector consists of several industries, which follow different dynamics. On the one hand, the fluctuation of the macro economy has distinctive effects on different high-tech industries; on the other hand, technological innovations in different industries, the drivers of growth in those industries, do not arrive simultaneously. As a consequence, different high-tech industries may follow unsynchronized business cycles. Therefore, at different points of time, the "hot spot" of growth may appear in different industries. For example, the 1990s saw a boom in the computer industry along with a decline in the defense industry. To catch upturns and avoid downturns in high-tech industries, a high-tech center such as Silicon Valley must accommodate rapid structural changes. This implies that a dynamic labor force is necessary. Previous research has emphasized the "high-velocity labor market" through which workers move frequently from one job to another within Silicon Valley. Such a labor market certainly helps the region's economy adapt to structural changes. In addition, a set of infrastructure and institutions that enables the labor force to quickly move into and out of Silicon Valley is also crucial for structural changes in the high-tech sector. For example, employment in the software industry in Silicon Valley increased from 48,500 to 114,600 between 1990 and 2001, a phenomenal 136 percent growth rate. It is impossible to train such a large number of technical workers within such a short period of time. This kind of rapid growth in a certain industry is achievable only through massive migration of the needed labor force.

Policy Implications

Our findings lead us to offer the following recommendations to policymakers.

Promote technological innovation. More than any other sector, the high-tech economy is about innovation and entrepreneurship. State and local governments should help promote innovation. Since university research has always been a major source of innovation, state government should continue its strong support to research universities. Big budget cuts for the University of California system will severely affect the prospect of the high-tech sector off campus, which must be avoided. Moreover, the California delegation in Washington, D.C., should place a high priority on securing R&D dollars for California from the federal government. As the state economy becomes more and more reliant on high-tech industries, support for R&D and innovation not only helps Silicon Valley and the rest of the Bay Area, but it also greatly benefits the Los Angeles and San Diego areas, which continue to expand their own high-tech sectors.

Encourage firm founding. Our findings show that although some firms do move out of Silicon Valley, it is not a serious problem. On the one hand, they are likely to move to nearby cities and stay within the state, and on the other hand, firm formation and growth create new jobs that overwhelmingly outnumber jobs lost by firm relocation. In addition, job creation in Silicon Valley is primarily achieved by new firms. Therefore, instead of worrying about losing firms because of the high costs of doing business in Silicon Valley, state and local governments should encourage firm founding. Offering favorable tax breaks, opening industrial parks, building high-tech incubators, and providing seed capital for commercialization of research are widely used policy levers. Continuously improving the quality of life in Silicon Valley and the Bay Area as a whole is also crucial for the vitality of the high-tech economy in this area.

Look beyond Silicon Valley. The high-tech sector is not a disconnected economy, nor is Silicon Valley an isolated region. Silicon Valley is well embedded in the San Francisco Bay Area economy as well as the state economy. Most of the firms leaving Silicon Valley migrate to

nearby cities in the Bay Area. The rest of the Bay Area has undoubtedly benefited from the proximity of Silicon Valley and has a quite strong high-tech economy. State policies regarding Silicon Valley should take into account connections between Silicon Valley and the rest of the state economy. For example, many people who work in Silicon Valley live a considerable distance from it, seeking more affordable homes. Thus, housing development and transportation policies in many other Bay Area cities help directly solve Silicon Valley's housing problems. We have also found that large firms in Silicon Valley hire only a small proportion of their total employees from the valley or even the Bay Area. This suggests that other regions in the state have chances to benefit from the spillover from Silicon Valley by hosting branches of its firms. State government could provide incentives for large firms to set up their manufacturing or distribution arms within the state. It is also helpful to improve transportation networks between the Bay Area and the Central Valley that facilitate Silicon Valley's branching out in other areas of the state. In addition, local governments in the rest of the Bay Area and the Central Valley should be more proactive in accommodating businesses branching out from Silicon Valley.

Maintain a dynamic labor pool. Two conflicting factors characterize the high-tech labor force. On the one hand, the high-tech sector primarily hires technical workers whose skills are highly specialized and take time to acquire; on the other hand, the high-tech sector is dynamic, with its core technologies evolving quickly. This implies that the skills acquired in school three years ago may be obsolete today. Moreover, certain high-tech industries often experience explosive growth, such as the software industry did in the 1990s, which creates a high demand for certain types of technical workers within a short period. Whether Silicon Valley can evolve rapidly hinges upon whether its labor force can quickly upgrade its skills or meet completely new demands. State government should continue to rely on local universities and community colleges as a vehicle to help retool the labor force continuously. Employers in Silicon Valley need to recruit new talent not only through local universities but also by hiring qualified immigrants, who have played an important role in Silicon Valley's growth. The immigrant pool has proved to be a major source of innovators and

entrepreneurs. Immigrants also provide a large reserve of high-quality engineers and scientists ready to satisfy sudden surges of demand in certain industries. State government in cooperation with federal authorities should keep the door open to international talent, both at local universities and in the high-tech industries. This has emerged as a particularly crucial issue because immigration policies have now entered the equation of homeland security.

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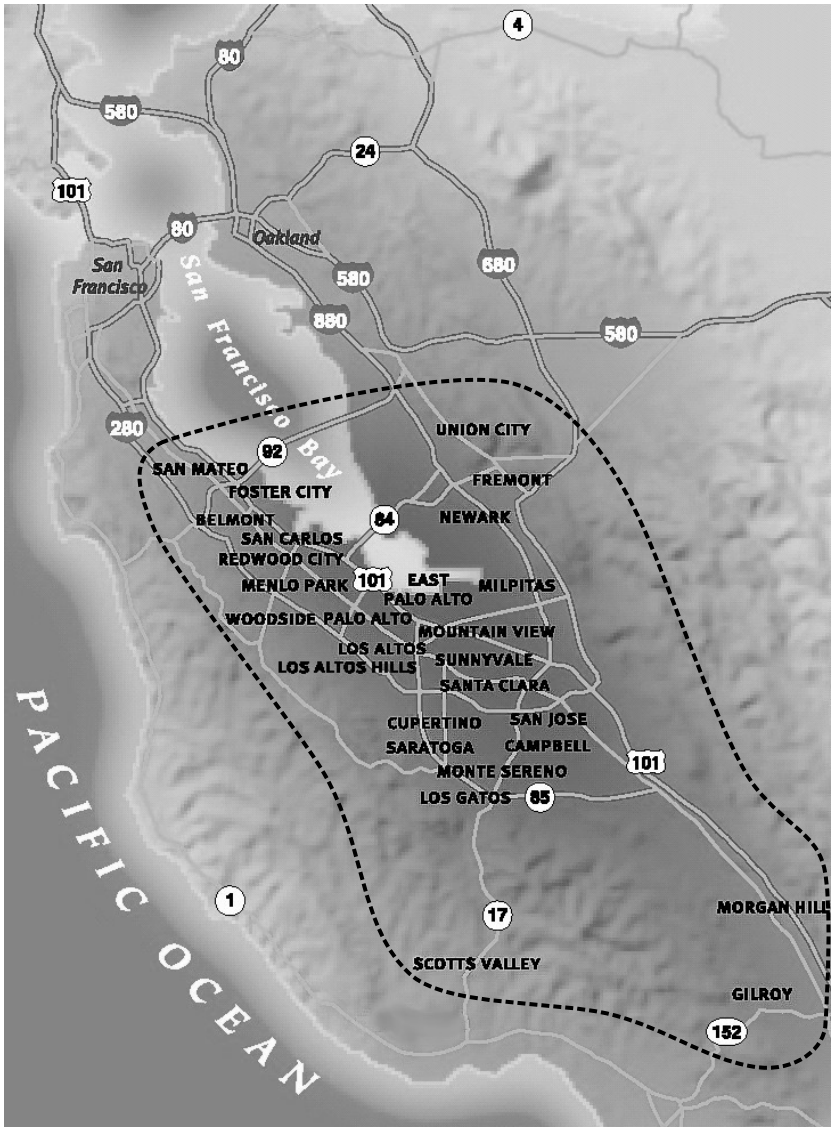
1. Introduction and Overview of the Study

It took merely half a century for Santa Clara Valley, the region that curls around the southern tip of the San Francisco Bay, to become the most famous high-tech industrial cluster in the world. Silicon Valley, as it has been known since the early 1970s, is today a main driver of the California state economy (see Figure 1.1 and Appendix A for our geographic definition of Silicon Valley). It is home to more than 22,000 high-tech companies, including household names such as Hewlett-Packard, Intel, Apple, and eBay.

Silicon Valley's celebrity skyrocketed over the past decade as it became the center of "the largest legal creation of wealth in history." At its peak, the Internet boom produced scores of new millionaires in Silicon Valley every day. The region had become a land of enchantment for ambitious entrepreneurs whose success stories appeared in the media all over the world, and thousands of well-paid jobs made Silicon Valley a magnet for talented people. Given the enormous success of this regional economy, policymakers around the world wondered how they could "clone Silicon Valley" in their own regions (Rosenberg, 2002).

But it seems that what goes up must come down. Since 2001, the region has entered a deep recession. In Santa Clara County, the heart of Silicon Valley, the unemployment rate climbed from 1.7 percent in January 2001 to 8.9 percent in October 2002, then declined a little to 8.3 percent in December 2002.[1] In 2002, Silicon Valley posted an annual unemployment rate higher than the state average for the first time in two decades. According to *Joint Venture's 2003 Index of Silicon Valley*, the region lost 127,000 jobs (about 9 percent of its total employment)

[1]According to the California Employment Development Department, available at http://www.calmis.cahwnet.gov/htmlfile/subject/lftable.htm.



SOURCE: Reprinted by permission from Joint Venture: Silicon Valley Network, with adaptations.

Figure 1.1—A Map of Silicon Valley

between the first quarter of 2001 and the second quarter of 2002. More than half of the job gains registered during 1998–2000 evaporated. At the same time, venture capital investment plummeted and personal income declined.

Policymakers, academic researchers, and the general public continue to puzzle over what made Silicon Valley such a huge success. More important, they wonder if the region will ever experience such strong growth again. This study seeks to answer those questions by examining Silicon Valley's high-tech economy in a dynamic context. Using two unique longitudinal databases, we investigate firm formation, growth, mortality, and migration in Silicon Valley during the 1990s and examine how the region's economy evolved and operated through such dynamic processes. This study not only helps us better understand Silicon Valley's success in the past, but it also reveals insights into how Silicon Valley can ensure its future prosperity.

Change in Silicon Valley

Silicon Valley has experienced both highs and lows many times. If asked to use a single word to characterize the Silicon Valley economy, many people would choose "dynamic." Indeed, change is the only unchanging norm in Silicon Valley, as new technologies and new firms constantly emerge. Yet, as the famous economist Joseph Schumpeter observed almost a century ago, innovations are not evenly distributed over time but occur in periodic clusters (Schumpeter, 1934). This is particularly true in Silicon Valley, which has remade itself over and over again during its short history ("Silicon Valley: How It Really Works," 1997; Henton, 2000).

Until the 1950s, only a handful of high-tech firms existed in the area, most notably Hewlett-Packard and Varian. The area was a major supplier of electronic devices to the Defense Department.

In the 1960s, as Fairchild spun off many semiconductor producers such as Intel and AMD, the area became a center of computer chipmakers, which later led to the name "Silicon Valley."

The late 1970s and 1980s were the computer years. By then the valley was known as a developer and manufacturer of personal computers and workstations, represented by such companies as Apple, Silicon Graphics, and Sun Microsystems.

In the 1990s, Silicon Valley remade itself again. This time, it helped commercialize Internet technology. The leaders of this movement included Cisco, Netscape, eBay, and Yahoo.

Silicon Valley has developed through waves of innovation, with a handful of innovative start-ups initiating each wave. In fact, the continuous success of Silicon Valley must be understood as the constant emergence of successful start-ups. As Lee et al. (2000) point out, "The Silicon Valley story is predominantly one of the development of technology and its market applications by firms—especially by start-ups. The result: new companies focused on new technologies for new wealth creation."

For many decades, social scientists have noticed the important role of start-ups in carrying out radical innovations. Schumpeter (1934, p. 66) observed that innovations are, as a rule, embodied in "new firms which generally do not arise out of the old ones but start producing beside them." Recent work has provided a rationale for this observation by emphasizing the characteristics of innovations. Foster (1986) argued that technological progress often exhibits discontinuities. That is, radical changes happen frequently. Reflected in the dynamics of high-tech industries, these discontinuities give new firms a so-called "attacker's advantage." When newcomers gain competitive superiority over successful incumbent firms, "leaders become losers." More recently, Christensen (1997) further developed this idea and called it the "innovator's dilemma."

When Schumpeter talked about "the incessant gales of creative destruction" many decades ago, he could not have imagined that the industry dynamics in Silicon Valley would provide such a vivid illustration of his notion. Silicon Valley is constantly creating the new while destroying the old. Table 1.1 lists the top 40 high-tech firms in Silicon Valley in 1982 and 2002. An overwhelming majority of the names on the 1982 list have become faded memories among the locals. To outsiders, most of the 1982 top firms are unrecognizable, because half

Table 1.1

Forty Largest Technology Companies in Silicon Valley, 1982 and 2002

1982	
1. Hewlett-Packard	21. Measurex[a]
2. National Semiconductor	22. Tandem[a]
3. Intel	23. Plantronics
4. Memorex	24. Monolithic
5. Varian	25. URS
6. Environtech[a]	26. Tab Products
7. Ampex	27. Siliconix
8. Raychem[a]	28. Dysan[a]
9. Amdahl[a]	29. Racal-Vadic[a]
10. Tymshare[a]	20. Triad Systems[a]
11. AMD	31. Xidex[a]
12. Rolm[a]	32. Avantek[a]
13. Four-Phase Systems[a]	33. Siltec[a]
14. Cooper Lab[a]	34. Quadrex[a]
15. Intersil	35. Coherent
16. SRI International	36. Verbatim
17. Spectra-Physics	37. Anderson-Jacobson[a]
18. American Microsystems[a]	38. Stanford Applied Engineering
19. Watkins-Johnson[a]	39. Acurex[a]
20. Qume[a]	40. Finnigan
2002	
1. Hewlett-Packard	21. Bell Microproducts[b]
2. Intel	22. Siebel[b]
3. Cisco[b]	23. Xilinx[b]
4. Sun[b]	24. Maxim Integrated[b]
5. Solectron	25. Palm[b]
6. Oracle	26. Lam Research
7. Agilent[b]	27. Quantum
8. Applied Materials	28. Altera[b]
9. Apple	29. Electronic Arts[b]
10. Seagate Technology	30. Cypress Semiconductor[b]
11. AMD	31. Cadence Design[b]
12. Sanmina-SCI	32. Adobe Systems[b]
13. JDS Uniphase	33. Intuit[b]
14. 3Com	34. Veritas Software[b]
15. LSI Logic	35. Novellus Systems[b]
16. Maxtor[b]	36. Yahoo[b]
17. National Semiconductor	37. Network Appliance[b]
18. KLA Tencor	38. Integrated Device
19. Atmel[b]	35. Linear Technology
20. SGI	40. Symantec[b]

NOTES: This table was compiled using 1982 and 2002 Dun & Bradstreet (D&B) Business Rankings data. Companies are ranked by sales.

[a]No longer existed by 2002.

[b]Did not exist before 1982.

of them no longer exist. Only four firms on the 2002 list are survivors from the 1982 list. In fact, more than half of the 2002 top firms were not even founded before 1982. In only two decades, the high-tech economy in Silicon Valley changed almost completely. The *San Jose Mercury News* has compiled a list of the top 150 firms in Silicon Valley each year since 1994. On average, each year's list includes 23 new firms, reflecting the fast pace of Silicon Valley.

A study of these "changes" is not only the key to understanding Silicon Valley's past success but also the key to promoting its future success. Silicon Valley's greatest asset is its ability to reinvent itself as soon as its leading technologies or products become standardized. Thus, the secrets of the region's success lie in its institutions that enable the changes. To ensure a bright future, we must identify, understand, and promote those institutions, and to understand the unique features of Silicon Valley and its institutions, we must observe its dynamic context.

A Demographic Perspective of the Silicon Valley Habitat

Silicon Valley is often described as a "habitat" (Lee et al., 2000) or an ecosystem (Bahrami and Evans, 2000). As in a natural habitat, Silicon Valley provides a host of resources that high-tech firms require to survive and grow. This habitat includes not only people, firms, universities and research institutions, and government agencies but also networks among those players and the modes by which they interact. Previous studies have examined different constituents of the habitat (see, for example, Saxenian, 1994; Kenney and Florida, 2000; and Lee et al., 2000). These studies have provided insights into the role played by entrepreneurs, universities, social networks, and supporting players such as venture capitalists, bankers, lawyers, consultants, and so on.

However, the central figure in the Silicon Valley habitat is undoubtedly high-tech firms. After all, the success of Silicon Valley is measured by the large population of high-tech firms that offer many well-paid jobs. Much like a biologist who studies animals in their natural habitats, we shall take a demographic approach to study firms in Silicon Valley.

The demographic approach is well developed in organizational sociology (Carroll and Hannan, 2000). In contrast to the bulk of literature in industrial economics that focuses on firm-level behavior, the demographic perspective shifts attention from individual firms to the range and diversity of firms in an industry or region. It seeks to discover insights into how industries evolve over time through processes of firm formation, growth, transformation, migration, and mortality. The demographic approach is not concerned with individual firms but, rather, focuses on properties at the population level, such as a population's age distribution and growth rates.

The demographic approach is particularly appropriate for studying the Silicon Valley economy. The high-tech sector in Silicon Valley consists of a wide range of firms. On one extreme are large companies offering thousands of local jobs, such as Hewlett-Packard and Intel; on the other are thousands of small firms that hire only a few people. Firms such as Hewlett-Packard and Varian have been around for more than six decades, whereas other high-profile firms such as eBay and Yahoo did not even exist ten years ago. Companies such as Cisco and Sun Microsystems have expanded at a stunning pace, whereas thousands of others hardly grow or disappear soon after inception. And most important, products or services are differentiated along many dimensions; rarely do any two firms provide exactly the same product or service.

As Carroll and Hannan have argued, the vibrancy of the Silicon Valley economy to some extent reflects its demographic characteristics. In particular, "the high rates of turnover of constituent organizations continually reshuffle the human workforce. The great diversity of organizational forms and technological strategies means that job-changers find themselves in new and different social contexts. Ideas flow with people, get recombined, and new technical and organizational innovations result. Analysis of a putatively representative firm would not only miss the point, it would also obscure community-level dynamics" (Carroll and Hannan, 2000).

Yet basic demographic facts about the Silicon Valley economy remain unknown, partly because of a lack of demographic data on industries. This means that the formulation of regional social and

economic policies usually ignores the implication of the full diversity of firms. Thus, a demographic study can yield very useful information for policymakers. For example, discussion of firm relocation usually draws upon anecdotal evidence from the media and often raises concerns about job loss. However, the relocating firms receiving media coverage are neither representative nor exhaustive. A statistical portrait of the whole population of moving firms would reveal the real effect of firm relocation.

Purpose of This Study

The purpose of this study is twofold. First, it will document the intensity of entrepreneurial activities in Silicon Valley and provide information helpful to understanding the dynamics of change in the region. Specifically, it will

- Measure the rates of firm formation, growth, and mortality in Silicon Valley and compare those rates to those in other high-tech centers.
- Measure the proportion of start-ups in the Silicon Valley economy and their effects on job creation and dissolution. These effects will be discussed in light of the Birch (1987) debate over whether small firms create more jobs.

The second purpose of this research is to track the stock and flow of high-tech firms in Silicon Valley. The study will

- Determine whether most firms move to the area or are started locally.
- Identify the characteristics of firms moving into or out of Silicon Valley.
- Examine whether net firm relocation enhances the cluster in Silicon Valley or causes the region to lose businesses.

Figure 1.2 summarizes industry dynamics in Silicon Valley's high-tech sector. We will investigate all of the types of dynamics illustrated, except for "moving inside" Silicon Valley, which is not a major concern of our study.

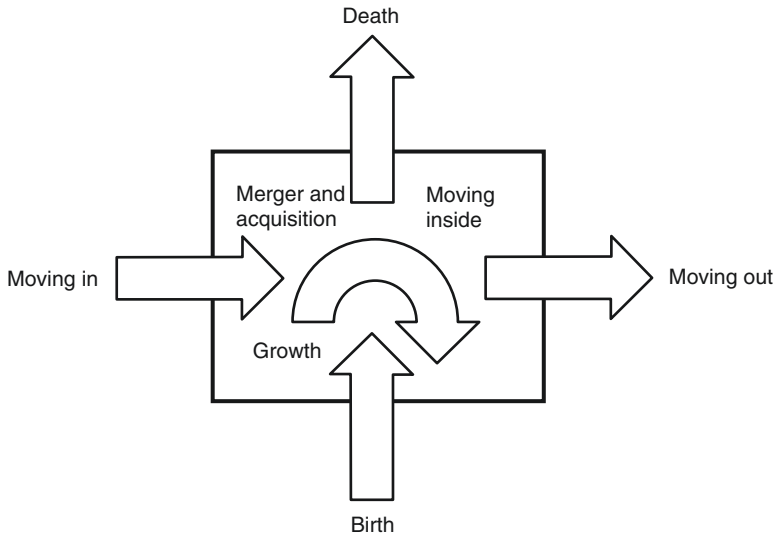


Figure 1.2—Industry Dynamics in Silicon Valley

Data

Our empirical analysis will rely on two longitudinal databases: The National Establishment Time-Series (NETS) dataset that seeks to include every firm in Silicon Valley and the nationwide VentureOne dataset that focuses on venture-backed firms. The two datasets contain an enormous amount of information that helps us better understand firm formation, growth, and industry dynamics in Silicon Valley. The abundance of data allows us to shed light on many important issues through simple descriptive analysis. For a detailed discussion of the data, see Appendix B.

2. Start-Up, Growth, and Mortality of Firms in Silicon Valley

The high-tech sector accounts for about 11 percent of the total goods and services in the United States (DeVol, 1999). As the most concentrated high-tech center, Silicon Valley has a much larger proportion of high-tech economy than does the rest of the nation. In 2001, there were 25,787 high-tech establishments in Silicon Valley—25 percent of the total establishments in the region. Since many high-tech firms are big employers, that one-quarter of all establishments offered 42.7 percent (or 673,000) of the total jobs in Silicon Valley. (See Appendix C for a more detailed profile of the Silicon Valley economy.)

This chapter documents firm formation, growth, and mortality in Silicon Valley's high-tech sector from 1990 to 2001, using the NETS dataset. Remember, the basic observation unit in the NETS data is the "establishment," and a big firm may have several establishments. When we study firm founding and mortality, we exclude establishments created by existing firms; and when we study firm growth, we aggregate all the establishments of a firm into a single unit.

Firm Formation

Rate of Firm Formation

Figure 2.1 traces the trend of entrepreneurial activities in Silicon Valley's high-tech sector. During the decade from 1990 to 2000, 29,000 high-tech firms were created in Silicon Valley. An upward trend started in the early 1990s and continued until 1998, before declining sharply in 1999 and 2000. It is interesting to note that only one-fourth of the new firms had ever hired five or more employees. Most of the new firms will always remain in the 0–4 size category. Some of the founders might be

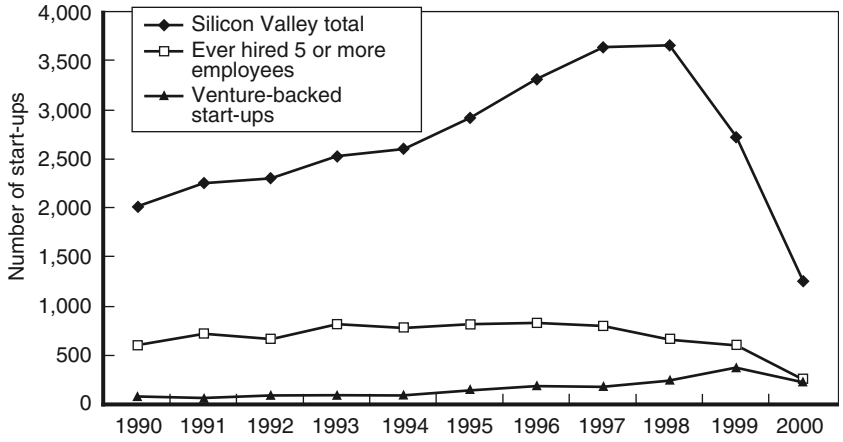


Figure 2.1—High-Tech Firm Formation in Silicon Valley, 1990–2000

more precisely described as self-employed rather than entrepreneurs. Firms that ever employed five or more people follow a much less dramatic trend in the 1990s. That is, although many more firms were created in the hype years of Internet technology, many of them started small and never grew.[1]

The trend for venture-backed start-ups is also depicted in Figure 2.1. Although the high-tech sector in Silicon Valley is mostly renowned for its legendary start-ups financed by venture capital, venture-capital-backed new firms actually form only the tip of a huge iceberg. A vast majority of

[1]D&B, the source of raw data, did ask each establishment to report its start year. However, not all of them did so. As a consequence, the start year is missing for many establishments, especially small ones. Walls & Associates created a variable "FirstYear," whose value is determined by the first time an establishment's data are available at D&B. If a firm reported to D&B in 1993 for the first time, 1992 is assigned to it as its first year. For those firms that have reported their start year, the first year variable is almost always identical to the start year. But overall, the trends in the two variables are quite different, mainly because many firms that were not in the D&B database originally later chose to be included in it for common reasons, such as needing a Data Universal Numbering System (DUNS) number. With the assumption that firms that reported their start year form a representative sample of the whole population, Figures 2.1–2.3 estimate the trend of entrepreneurial activities using the number of start-ups whose start year is self-reported. For example, if x out of *y* start-ups reported their start year in the whole sample and z of them reported 1995 as their start year, the number of firms started in 1995 is estimated to be z*y/x. By doing so, we smooth out the noise in the trend created mainly by small firms.

high-tech firms created in Silicon Valley are not financed by venture capital, either because they are not capital-intensive enterprises or because they do not possess a growth potential that justifies venture capital support. However, the number of venture-backed new firms grew faster proportionately than the overall trend of firm formation in the high-tech sector. In 1999, the peak year of venture capital finance, 375 start-ups were backed by venture capital—more than five times the number in 1990—whereas the total number of new firms founded in the high-tech sector did not even double from 1990 to its peak year in 1998. This reflects the fact that venture capital became much more easily available in the late 1990s. It also suggests that firm founders became more innovative as the Internet revolution created many new opportunities. We study venture-backed firms exclusively in the next chapter.

Figure 2.2 compares the trend of firm formation in Silicon Valley to the trends in Boston and Washington, D.C.[2] From 1990 to 1996, the

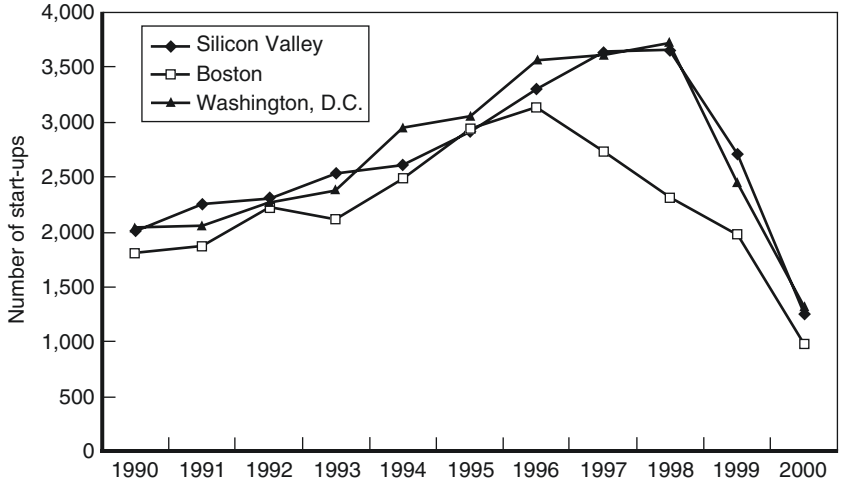


Figure 2.2—Firm Formation in High-Tech Clusters, 1990–2000

[2]By high-tech employment, Silicon Valley, Boston, and Washington, D.C., are the top three, far ahead of any other high-tech center in the United States (Cortright and Mayer, 2001). This is the primary reason why we choose Boston and Washington for comparison.

three areas followed almost the same upward trend. Boston lost its momentum in 1996, but Silicon Valley and Washington, D.C., continued their upward trend in firm formation until 1998. The Internet boom in the late 1990s stimulated more entrepreneurial activities in Silicon Valley and Washington than in Boston.

Figure 2.3 traces the founding year of those new firms that had ever hired five or more employees in the three high-tech clusters. Silicon Valley has more firms in the 5+ category. Whereas the total number of new firms founded in Silicon Valley follows a similar trend as in the other two high-tech regions, the former consistently has more young firms hiring five or more employees. This may suggest that new firms in Silicon Valley are more growth-oriented than those in the other two areas.

As mentioned above, 29,000 high-tech firms were created in Silicon Valley during the decade from 1990 to 2000. Washington, D.C., had a similar total, and Boston had about 5,000 fewer new firms. Table 2.1 presents the distribution of new firms across major high-tech industries (see Appendix A for exact definitions of those industries). In all three

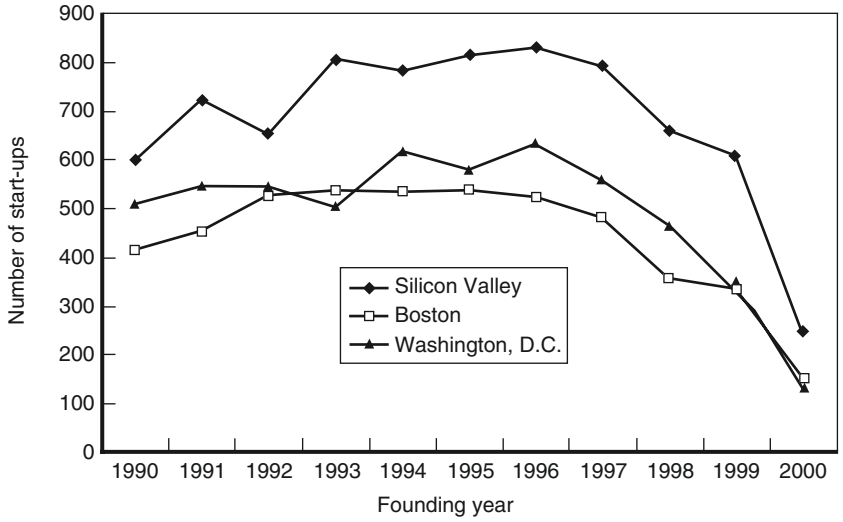


Figure 2.3—High-Tech Start-Ups That Ever Hired Five or More Employees by 2001

Table 2.1

High-Tech Start-Ups, by Industry, 1990–2000

	Silicon Valley		Boston		Washington, D.C.	
Industry	Firms	%	Firms	%	Firms	%
Bioscience	586	2.0	335	1.4	211	0.7
Computers/communications	934	3.2	221	0.9	172	0.6
Defense/aerospace	52	0.2	27	0.1	35	0.1
Environmental	242	0.8	299	1.2	174	0.6
Semiconductor	513	1.8	52	0.2	28	0.1
Software	5,967	20.4	3,323	13.5	4,137	14.0
Professional services	14,009	47.9	16,784	68.2	19,703	66.9
Innovation services	6,944	23.7	3,565	14.5	4,985	16.9
Total	29,247	100	24,606	100	29,445	100

NOTE: Percentages may not sum to 100 because of rounding.

regions, the service industries were the most active. About 70 percent of Silicon Valley new firms were engaged in professional or innovation services. The percentage is even higher in the other two areas: for each, more than 80 percent of new firms were established in service industries. Except in the environmental industry, Silicon Valley outperformed the other two areas in every nonservice industry. Silicon Valley created more firms in the biotech, computers/communications, defense/aerospace, semiconductor, and software industries. Silicon Valley strongly led the semiconductor industry, from which it acquired its name, with 513 semiconductor start-ups during the decade, compared to 80 in Boston and Washington together. Although Boston has a long history in the defense industry and hosts Raytheon as the area's largest employer, fewer defense/aerospace firms were founded in Boston than in the other two areas. It is also very impressive that Washington outperformed Boston (supposedly the number two high-tech cluster) in the software industry. Boston is also well known for its biotech industry. However, even in biotech, it was outnumbered by Silicon Valley. Remember, the biotech industry in the Bay Area is mainly clustered around South San Francisco and Berkeley–Emeryville, which is outside Silicon Valley. Taking that into account, the whole Bay Area did much better in biotech than reflected in the number for Silicon Valley alone.

Structural Changes

In the high-tech sector, different industries serve different markets and employ workers with different skills. The labor forces in different industries are not entirely interchangeable. Thus, a high-tech center tends to retain a stable economic structure over time. Yet innovations do not arrive at the same rate across all industries and the macro economic climate may also have different effects on different industries. A vibrant high-tech center needs to be flexible and able to shift its emphasis when some industries slow down and others become more dynamic. Otherwise, it will not take full advantage of new areas of growth and will be hard hit when a major industry shrinks. Given the size of its high-tech sector, Silicon Valley appears to be exceptionally adaptable in accommodating structural changes.

Figure 2.4 presents the evolution of employment in high-tech industries in Silicon Valley. Two developments in the 1990s redefined the high-tech sector: the reduction of defense spending by the federal government after the end of the Cold War and the Internet revolution. Both have left clear marks on the structure of Silicon Valley's high-tech economy. During 1990–2001, Silicon Valley's defense/aerospace industry lost 60 percent of its jobs; in contrast, the software industry grew by 136 percent and the computers/communications industry by 32 percent.

In 1990, total high-tech employment in Silicon Valley was 90 percent larger than in Washington, D.C., and 26 percent larger than in Boston, yet it was nimble enough to substantially change the structure of its high-tech economy over the next decade. The 136 percent growth of the software industry in Silicon Valley outpaced every high-tech industry in the other two regions. At the same time, Silicon Valley's defense/aerospace industry was the most heavily hit and shrank the most. For each industry, we decompose the employment growth during 1990–2001 into the growth of firms that existed in 1990 and the jobs added by firms founded after 1990. In 2001, the high-tech economy in Silicon Valley had 672,825 employees—26 percent more than its total employment in 1990. Software, computers/communications, professional services, and semiconductor industries had each created more than 20,000 jobs. If we look only at those firms that already

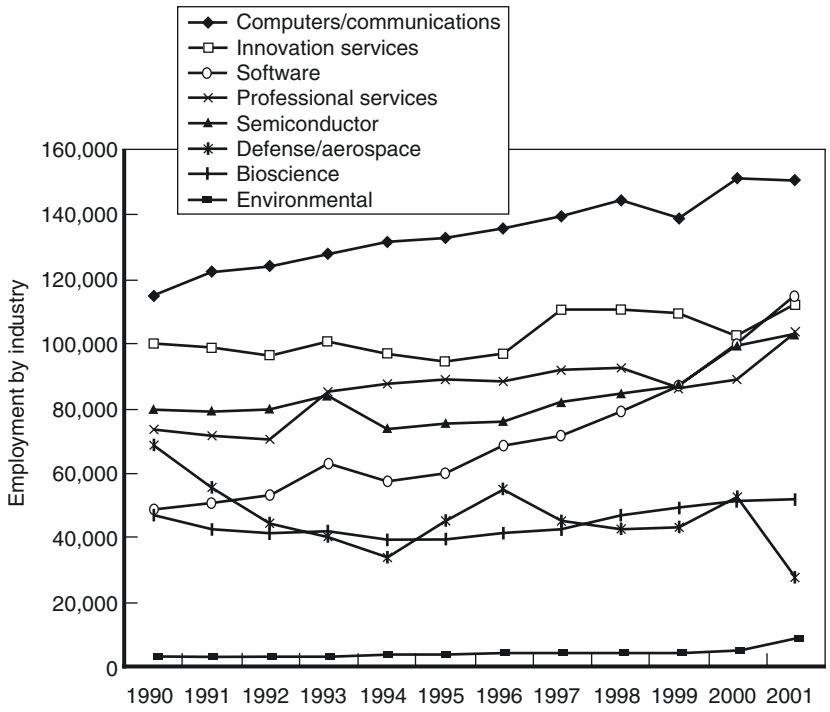


Figure 2.4—Employment in High-Tech Industries in Silicon Valley, 1990–2001

existed in 1990, they together lost 120,559 jobs. Old firms hired more people only in the semiconductor and environmental industries, but both increases were modest. It is interesting to note that firms founded before 1990 lost jobs during 1990–2001 in software and computers/communications—the two industries that gained the most jobs in Silicon Valley during the 1990s (Table 2.2).

On the other hand, firms founded after 1990 added a total of 258,796 jobs to the economy during the 1990s. The 136 percent growth of the software industry was all attributable to new firms, which added 72,684 jobs to the industry. In 1990, the software industry was number six by employment in Silicon Valley, after the computers/communications, innovation services, semiconductor, professional

Table 2.2

Employment in High-Tech Industries in Silicon Valley, 1990–2001

Industry	Employment in 1990 (1)	2001 Employment of Firms Existing in 1990 (2)	Total Employment in 2001 (3)	Overall Employment Growth 1990–2001 (3) – (1)	Employment Growth of Firms Existing in 1990 (2) – (1)	Employment Growth of New Firms (3) – (2)
Bioscience	46,815	36,243	51,854	5,039	–10,572	15,611
Computers/communications	114,617	104,956	150,974	36,357	–9,661	46,018
Defense/aerospace	68,527	22,251	27,567	–40,960	–46,276	5,316
Environmental	2,851	3,246	8,342	5,491	395	5,096
Semiconductor	79,630	83,701	103,443	23,813	4,071	19,742
Software	48,529	41,955	114,639	66,110	–6,574	72,684
Innovation services	100,217	65,389	112,150	11,933	–34,828	46,761
Professional services	73,402	56,288	103,856	30,454	–17,114	47,568
Total	534,588	414,029	672,825	138,237	–120,559	258,796

services, and defense/aerospace industries. By 2001, only the computers/communications industry had more employees.

Old firms lost jobs because not all of them survived after ten years. Also, other old firms might still be growing, but the growth occurred outside Silicon Valley. Table 2.2 provides a clear indication that Silicon Valley shifts development paths and remakes itself through the formation and growth of new firms.

Firm Growth

Because of the lack of sales data, firm growth is measured by employment growth.

Tables 2.3 and 2.4 present the average employment of high-tech firms that are still alive. Firm sizes in service and other industries are calculated separately. On average, a high-tech start-up in nonservice industries hires 7–22 persons in the first year, depending on the cohort. As the start-up becomes older, its average employment is larger. In contrast to our general impression, the average growth of start-ups is far from explosive. It generally takes 5–6 years for an average start-up to double its employment.

Firms in service industries are generally smaller and experience much slower growth. Before 1997, new firms in service industries always had an average employment below five in the first year. It takes more than nine years for service firms to double their average employment. A majority of them hardly grow at all. The growth is underestimated because the employment at a firm's branches outside Silicon Valley is not captured here because of data limitations. Yet the number is meaningful because it measures the growth of start-ups within Silicon Valley. The growth is not accelerating as the data might have suggested. The faster growth at older ages results because many firms were defunct by those ages and only the fast-growing firms survived and were counted. Tables 2.3 and 2.4 suggest that the kind of explosive growth achieved by such stars as eBay and Yahoo is phenomenal, even by Silicon Valley's standard.

Figures 2.5 and 2.6 compare the size of high-tech firms in Silicon Valley with those in the Boston and Washington, D.C., areas. Nonservice high-tech firms seem to grow faster in Silicon Valley. Each

Table 2.3

Growth of Silicon Valley's High-Tech Firms in Nonservice Industries

	Average Employment										
Cohort	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1990	12.48	12.58	12.59	14.96	15.77	21.51	26.50	30.27	40.54	48.18	55.74
	(58.83)	(58.93)	(59.03)	(63.73)	(65.15)	(96.69)	(114.3)	(127.6)	(234.5)	(281.1)	(314.3)
1991		8.22	8.41	9.70	11.52	12.40	16.95	18.78	21.86	27.16	35.15
		(11.76)	(12.09)	(14.17)	(19.54)	(20.07)	(36.36)	(42.69)	(53.11)	(64.50)	(98.79)
1992			7.34	8.05	9.23	10.46	12.95	15.47	17.99	21.74	22.90
			(10.73)	(12.09)	(14.23)	(17.84)	(23.35)	(30.32)	(35.73)	(58.63)	(60.93)
1993				8.53	9.09	9.85	12.40	15.78	18.43	24.57	35.58
				(14.28)	(14.82)	(15.01)	(18.59)	(24.28)	(30.52)	(81.62)	(119.1)
1994					9.25	10.06	11.07	13.61	16.55	20.60	28.19
					(13.27)	(15.34)	(16.39)	(20.35)	(26.58)	(34.46)	(68.31)
1995						9.58	10.09	13.68	16.68	20.29	28.61
						(16.14)	(16.15)	(22.67)	(34.65)	(41.17)	(58.32)
1996							10.24	11.66	15.00	21.00	29.12
							(26.60)	(28.02)	(33.43)	(50.53)	(66.00)
1997								9.01	9.65	12.66	20.97
								(16.83)	(18.56)	(24.43)	(67.43)
1998									8.41	10.85	17.23
									(13.53)	(23.92)	(49.50)
1999										20.78	20.29
										(141.8)	(117.1)
2000											22.51
											(149.2)

NOTE: Standard deviations are in parentheses.

Table 2.4

Growth of Silicon Valley's High-Tech Firms in Service Industries

	Average Employment										
Cohort	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1990	4.88	4.90	4.93	4.98	5.60	5.44	6.17	6.70	7.52	7.90	12.47
	(13.66)	(13.65)	(13.70)	(14.22)	(22.26)	(15.96)	(20.73)	(22.11)	(26.35)	(29.12)	(83.00)
1991		4.30	4.26	4.55	4.69	5.06	5.69	6.52	6.71	6.18	6.75
		(8.07)	(7.98)	(9.43)	(10.0)	(10.28)	(13.53)	(17.84)	(18.42)	(13.78)	(15.17)
1992			4.28	4.46	4.58	4.87	5.85	5.89	6.26	6.62	6.82
			(8.82)	(9.04)	(9.37)	(10.30)	(15.49)	(16.07)	(17.08)	(17.52)	(19.00)
1993				4.65	4.80	5.14	5.56	5.88	5.90	5.93	6.29
				(9.34)	(9.77)	(10.77)	(11.70)	(15.32)	(12.71)	(12.36)	(14.13)
1994					4.74	4.68	4.83	5.17	5.88	5.84	5.77
					(8.60)	(8.06)	(8.31)	(9.06)	(13.54)	(11.64)	(11.22)
1995						4.70	4.91	5.53	5.98	6.12	6.97
						(9.38)	(9.70)	(11.42)	(13.08)	(13.12)	(18.79)
1996							4.45	4.72	5.08	5.66	6.28
							(10.32)	(11.26)	(10.35)	(12.31)	(14.43)
1997								6.61	6.80	7.35	8.77
								(61.29)	(61.79)	(62.98)	(66.70)
1998									3.98	4.18	5.13
									(7.75)	(7.96)	(12.80)
1999										6.77	7.68
										(17.90)	(19.92)
2000											12.93
											(126.5)

NOTE: Standard deviations are in parentheses.

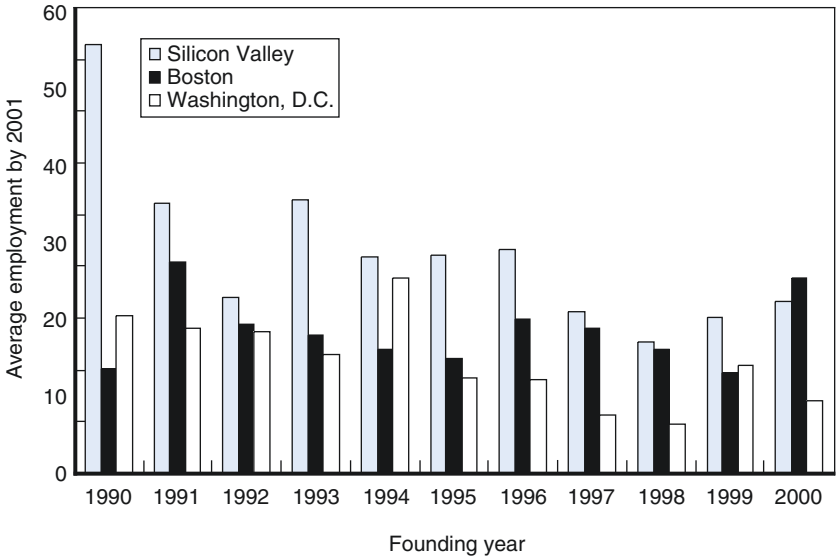


Figure 2.5—Employment of High-Tech Start-Ups in Nonservice Industries, 2001

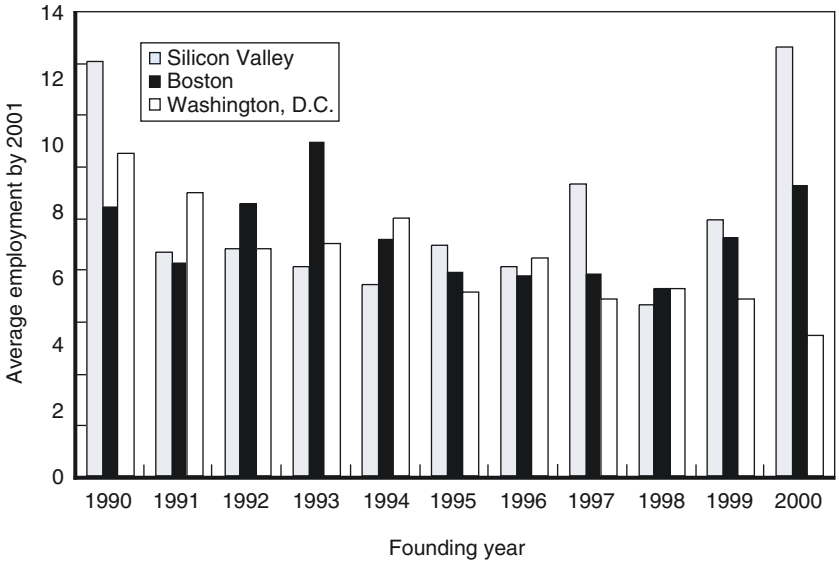


Figure 2.6—Employment of High-Tech Start-Ups in Service Industries, 2001

cohort of nonservice firms founded during 1990–1999 has higher average employment in Silicon Valley. The 2000 cohort, only one year old in our data, is the only group of Silicon Valley nonservice firms that does not dominate its counterparts in the other two regions by employment size. This may suggest that Silicon Valley's nonservice high-tech firms start with a smaller employment size but grow faster. In service industries, Silicon Valley high-tech firms are not consistently larger than those in other areas. In three cohorts, Silicon Valley firms have the smallest average employment; yet in five others, Silicon Valley firms have the largest. Silicon Valley service firms founded in the late 1990s seemed to do particularly well, which may be attributable to the Internet boom that especially benefited Silicon Valley. Figure 2.5 also shows that service firms are quite similar in size across different cohorts, which implies that they grow slowly over time.

This section has demonstrated that start-ups in nonservice industries grow faster than those in service industries, and the previous section has shown that a higher proportion of start-ups in Silicon Valley occurs in nonservice industries. These together provide another reason why more firms in Silicon Valley than in Boston or Washington, D.C., had hired five or more employees by 2001 (Figure 2.3).

Firm Mortality

In the general practice of corporate demography literature (Carroll and Hannan, 2000), the mortality of a firm refers to any event by which a firm loses its identity. For example, a firm may disband, exit to another industry, or be merged or acquired. In this study, we are particularly interested in the disbanding of firms, since it has implications for the job market. We consider a firm dead if it drops out of the D&B dataset, since most probably it disbanded. A firm that has shifted to a different industry will simply have a new standard industrial classification (SIC) number. Those that go through merger and acquisition will simply have a different "headquarter DUNS number." Neither will drop out of the D&B database.

Firms do change their businesses sometimes. Among high-tech start-ups founded in Silicon Valley since 1990, 4.65 percent had changed their eight-digit SIC numbers at least once by 2001. For Boston and

Washington, D.C., the number was 2.59 percent and 2.54 percent, respectively. Although a high percentage of changing SIC numbers may imply a fast-changing local economy, we have little information to tell why firms exit to other industries.

Rate of Mortality

Table 2.5 describes the death of high-tech establishments by size between 1990 and 2000. Between 30 and 50 percent of establishments died during those 11 years. Establishments that hire fewer than 20 people have a higher chance of failing and hence provide less job security to their employees. Those with over 5,000 employees are also more likely than midsized establishments to fail, although the small sample size of establishments in that category suggests caution in the comparison. Although small establishments are more likely to disappear, the death of large establishments has a much greater effect on the labor market. Whereas the death of 21,967 establishments under size 20 left 84,453 people jobless, the death of 18 establishments with more than 2,500 employees eliminated 102,518 jobs.

Figure 2.7 plots the survival rates of high-tech start-ups in Silicon Valley during 1990–2000. Nonservice start-ups have higher survival

Table 2.5

Death of High-Tech Establishments in Silicon Valley, 1990–2000

Establishment Size	Establishments in Sample	Establishments Dead by 2001	% Died	Job Loss by Death
0–4	33,277	16,933	50.9	40,530
5–9	6,722	3,142	46.7	19,805
10–19	4,386	1,892	43.1	24,118
20–50	3,867	1,521	39.3	47,149
51–100	1,423	557	39.1	42,572
101–250	948	331	34.9	54,505
251–500	368	151	41.0	54,248
501–1,000	138	42	30.4	32,400
1,001–2,500	107	42	39.3	72,234
2,501–5,000	30	12	40.0	46,800
5,000+	13	6	46.2	55,718

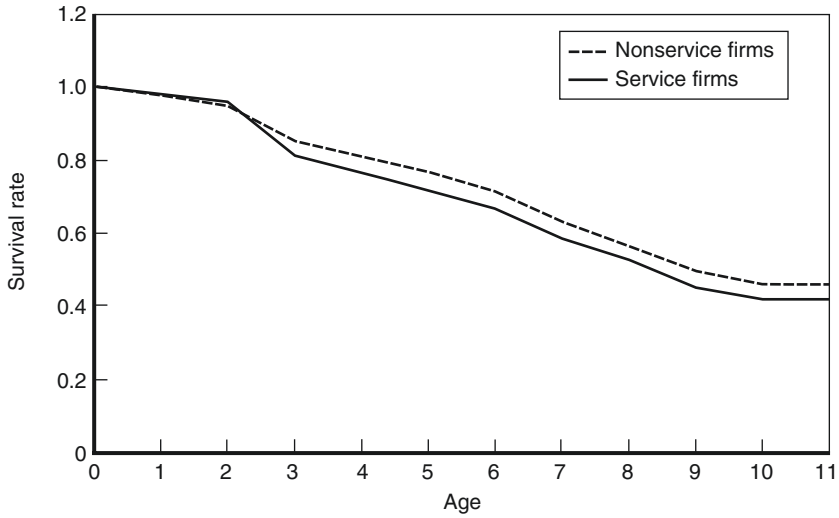


Figure 2.7—Survival Rates of High-Tech Firms in Silicon Valley

rates than service firms in the long run. About 76 percent of the nonservice start-ups and 72 percent of service start-ups are still alive at age five. Only 46 percent of nonservice firms and 42 percent of service firms are still in business at age ten. The third year seems to be the most dangerous age. About 15 percent of Silicon Valley's high-tech start-ups in service industries and 9 percent of those in nonservice industries died at that age.

Figure 2.8 compares the survival rates of high-tech firms in Silicon Valley, Boston, and Washington, D.C. In nonservice industries, the survival rates are almost identical in the three areas. In service industries, firms in Silicon Valley have a better chance to survive than those in the other two regions. The relative size of the service industries is larger in Boston and Washington (Table 2.1), which may imply that service firms in those areas are less efficient or face harsher competition and hence have lower survival rates.

Merger and Acquisition

Acquisition is the generic term used to describe a transfer of ownership. A corporate acquisition occurs when a buyer purchases the stock or assets of a corporation. A merger has a strict legal meaning that

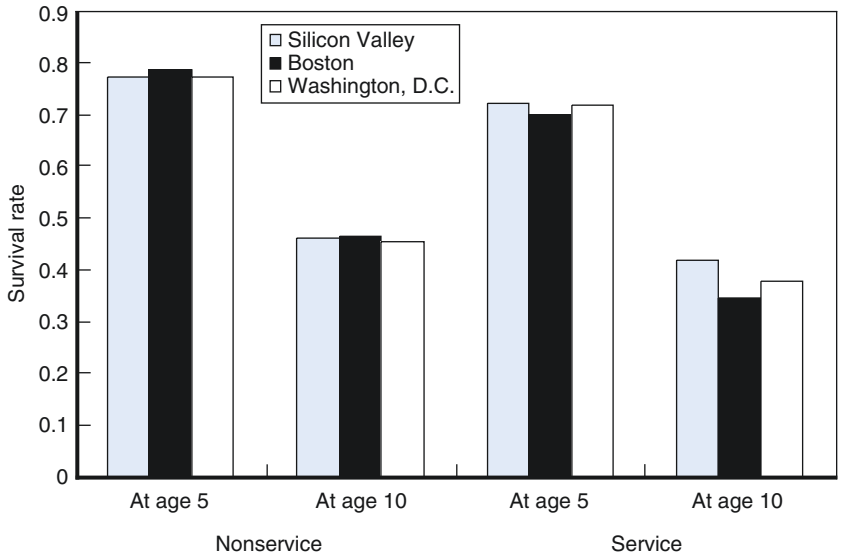


Figure 2.8—Comparison of Survival Rates

refers to the process in which one corporation is combined with and disappears into another. All mergers occur as specific transactions in accordance with the laws of the states where the firms are incorporated. Merger is a narrow technical term for a particular legal procedure that may or may not happen after an acquisition. The post-deal manner of operating or controlling a firm has no bearing on whether a merger has occurred. With regard to the NETS dataset, we consider a merger or acquisition to have happened if a firm is not a "branch" or "subsidiary" at its starting year but becomes a "branch" or "subsidiary" at the ending year.[3]

Figure 2.9 shows the percentage of high-tech firms acquired in each region by 2001. Note that the cohort year refers to the founding date of the firms that were acquired. The acquisition did not necessarily happen that year. In most cases, the acquisition happened a few years later. Overall, firms in Silicon Valley are most likely to change ownership.

[3]Alternatively, we could say a firm has changed ownership through M&A if it now has a "headquarter DUNS number" different from its own DUNS number. This gives almost identical results.

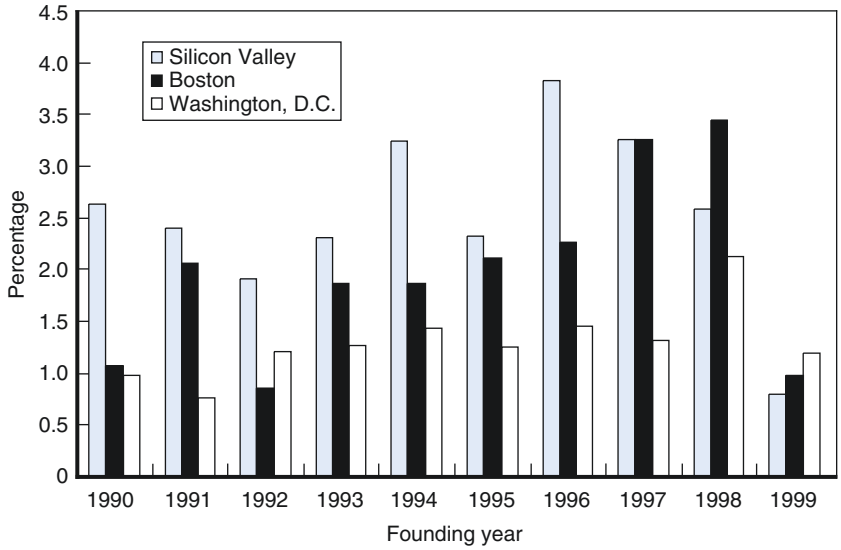


Figure 2.9—Percentage of Firms Acquired by 2001

Those in Washington, D.C., are least likely to be acquired. Among each cohort in each region, less than 4 percent of firms founded in the 1990s had been acquired by 2001. This is a relatively small number compared to how many had gone out of business. As we see in the next chapter, venture-backed firms are much more likely to be bought.

Table 2.6 lists the top headquarter states whose firms tend to acquire high-tech start-ups in the three high-tech regions. Not surprisingly, a large proportion of the start-ups were acquired by local firms: California firms top the acquisition list in Silicon Valley, Massachusetts firms bought more high-tech start-ups in the Boston area, and firms in Virginia and Maryland acquired more high-tech start-ups in the Washington, D.C., area. Whereas California firms bought 56 percent of the start-ups acquired in Silicon Valley, Massachusetts firms acquired only 36 percent of those in the Boston area. In Washington, D.C., firms in Maryland, Virginia, and the city Washington bought 45 percent of the firms. Firms in California, New York, New Jersey, and Massachusetts have a strong showing in all three high-tech centers, which probably reflects the fact that those states have more established high-tech companies than other states.

Table 2.6

Top Headquarter States of Firms Acquired During 1990–2001

	Silicon Valley (Total: 1,376)		Boston (Total: 965)		Washington, D.C. (Total: 814)	
	State	Cases	State	Cases	State	Cases
1	California	769	Massachusetts	350	Virginia	211
2	New York	97	California	134	Maryland	124
3	Massachusetts	69	New York	115	California	81
4	New Jersey	45	New Jersey	32	New York	72
5	Texas	45	Texas	32	New Jersey	37
6	Pennsylvania	36	Illinois	31	Massachusetts	36
7	Florida	26	Connecticut	28	Texas	33
8	Illinois	26	Pennsylvania	27	Washington, D.C.	29
9	Minnesota	24	Florida	20	Florida	23
10	Virginia	22	Maryland	17	Pennsylvania	23

Job Creation by Start-Ups

In this study, we refer to firms that are five years old or younger as start-ups. When new firms are founded, they create jobs. Yet many start-ups fail long before they become mature, thereby eliminating jobs. To pick up the net effect, we track the total employment of high-tech start-ups younger than certain ages, which is presented in Figure 2.10. Since 1995, high-tech start-ups in Silicon Valley have offered ever-increasing numbers of jobs. In 1995, 47,200 employees worked for high-tech start-ups younger than two years old. By 2001, that number increased to 69,200. In 1998, start-ups younger than age five offered 132,500 high-tech jobs; the number had risen to 159,300 by 2001.

To assess the relative importance of start-ups as job creators, we calculate the employment of start-ups younger than age five as the percentage of total high-tech employment in Silicon Valley and compare it with the same measure for the Boston area and Washington, D.C. (Figure 2.11). During 1998–2001, start-ups younger than age five consistently accounted for more than 20 percent of the high-tech employment in Silicon Valley. The percentage increased from 21.9 percent in 1998 to 23.7 percent in 2001. This means that jobs offered by start-ups grew faster than the total high-tech sector in the valley. The measure for Boston is a little higher and more stable—about 24 percent

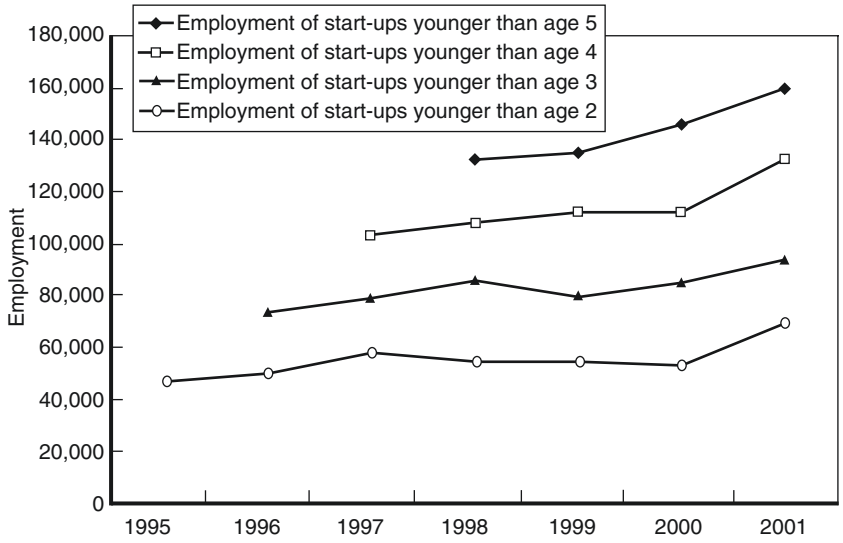


Figure 2.10—Employment of High-Tech Start-Ups in Silicon Valley

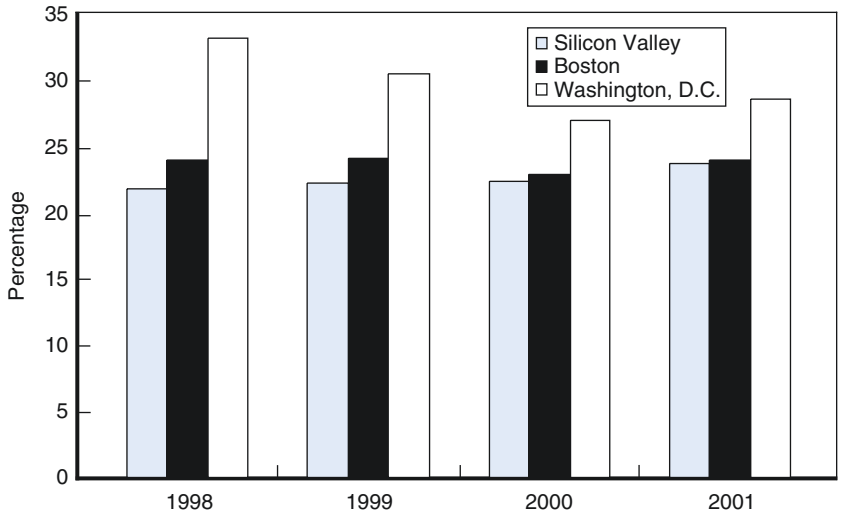


Figure 2.11—Employment of High-Tech Start-Ups Younger Than Age Five as a Percentage of Total High-Tech Employment

during the four years. The measure in the Washington, D.C., area is significantly higher than those in the other two regions. In 2001, start-ups offered 128,200 jobs in Washington, D.C., which amounted to 28.6 percent of the total employment in high-tech industries. In 1998, the percentage was even higher, when one out of every three employees in the high-tech sector worked for a start-up that was younger than five years old.

Conclusion

The whole picture of entrepreneurial activities, as presented here, differs somewhat from the public's general impression. The media tend to direct attention to a small group of venture-backed firms. In fact, thousands of new firms are founded each year in Silicon Valley; venture-backed start-ups represent only a small proportion of the total. The public is too familiar with stories about the explosive growth of Silicon Valley start-ups but, in fact, a large proportion of every cohort of new firms founded in the valley will never hire more than five people. High-tech start-ups in service industries grow slower than other high-tech start-ups. Start-ups have been major job creators in Silicon Valley during the past decade; firms founded after 1990 created almost all the new jobs added to the region's high-tech sector during 1990–2001. However, even during the decade characterized by the Internet boom, firm mortality rate was quite high in Silicon Valley. More than half of the firms started during the decade went out of business by age ten.

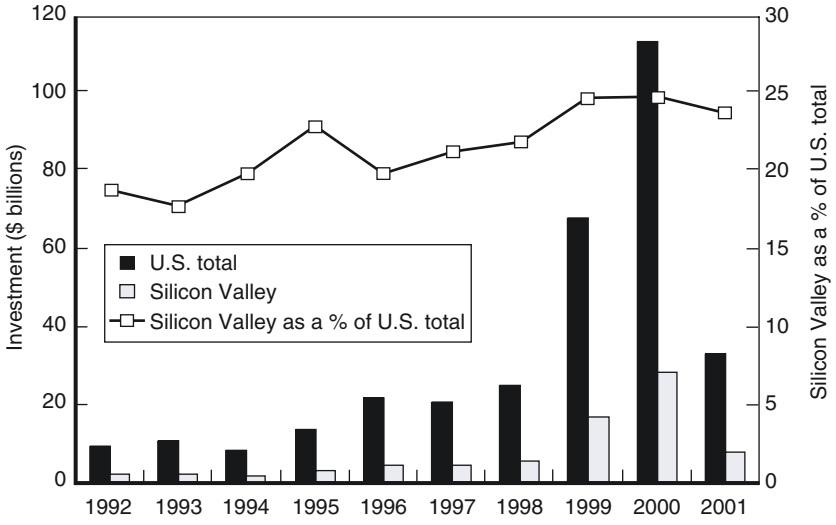
3. Venture-Backed Start-Ups in Silicon Valley

This chapter examines venture-capital-backed start-ups, which are more innovative and growth-oriented than other high-tech start-ups. Venture capital refers to money managed by professionals who invest in young, rapidly growing companies that have the potential to develop into significant economic contributors. Venture capital is an important source of equity for start-up companies, particularly in the high-tech sector.

In the San Francisco Bay Area, there has been a long tradition of wealthy people financing new technology firms. Yet, professional venture capital activity started later in the Bay Area than in the Boston area (Bygrave and Timmons, 1992; Kenney and Florida, 2000). In 1957, when Robert Noyce and seven fellow engineers left Shockley Semiconductor Laboratories to start their own business, they had to go to the East Coast to look for capital. The first West Coast venture capital firm—Draper, Gaither & Anderson—was not founded until 1958. The venture capital industry grew hand in hand with the high-tech industries in Silicon Valley. Since the 1960s, venture capitalists have been involved in every major successful company. Today, venture capital has become an intrinsic part of any story about Silicon Valley. Sand Hill Road in Menlo Park, the cluster of Silicon Valley's venture capital firms, is virtually synonymous with venture investing.

Venture Capital in Silicon Valley

Figure 3.1 traces the nominal amount of venture capital invested in the United States and Silicon Valley over the ten years from 1992 to 2001. The trend is characterized by two big jumps and one severe crash. Between 1992 and 1994, venture capital investment first increased from $9.2 billion to $10 billion and then dropped to $8 billion. Compared to



SOURCE: Author's calculations from the VentureOne database.

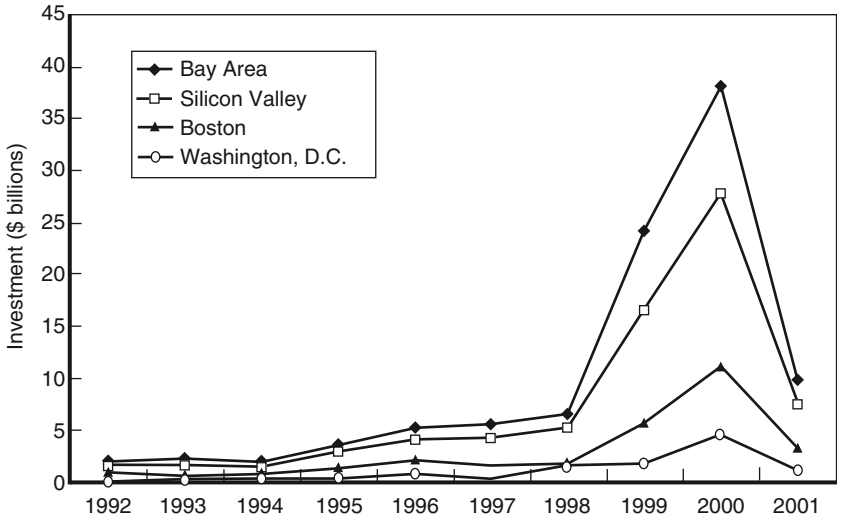
Figure 3.1—Total Venture Capital Investment, 1992–2001

what happened later, this 10 percent increase and 20 percent decline seem to be negligible changes. Between 1994 and 1996, venture capital investment first experienced a 66 percent increase over the year, followed by another 59 percent growth. During these two years, venture capital investment jumped from $8 billion to $21.3 billion, stimulated by the promising Internet revolution. The year 1997 was relatively quiet, with venture capital investment dropping slightly to $20.4 billion. The next three years can only be described as mania: Venture capital investment increased first by 20 percent, then by 173 percent, and finally by 66 percent, ending with a total of $112.2 billion in 2000. In nominal dollars, venture capital investment in 2000 was 14 times as much as it was in 1994. This mirrors the Internet bubble seen in the NASDAQ index. The burst of the bubble is also reflected in venture capital investment. In 2001, the total crashed down to $32.5 billion, a 71 percent decline. Yet, in spite of this big falloff, the year 2001 still represents the third most heavily invested year in venture capital history.

Venture capital invested in Silicon Valley followed a similar trend over the ten years. At its peak in 2000, Silicon Valley attracted nearly

$28 billion of venture capital investment. The decline in investment in 2001 also appeared in Silicon Valley. Still, the $7.7 billion invested in that year is the third-largest number the region has ever witnessed, second only to the venture investments in 1999 and 2000. In terms of the proportion of the U.S. total, Silicon Valley's share has increased over the decade. In 1992, 18.7 percent of the total investment took place in Silicon Valley; in 1993, the number dropped slightly to 17.6 percent. Yet at its peak in 2000, Silicon Valley accounted for 24.8 percent of the U.S. total.

Figure 3.2 compares Silicon Valley with the Bay Area as a whole, the Boston area, and Washington, D.C. Boston and Washington also experienced a large increase in venture capital investment during the late 1990s, following the national trend. However, the increases in Boston and Washington are not nearly as sharp as those in Silicon Valley and the Bay Area. It is particularly worth noting that the trend in the Bay Area shot up higher than that in Silicon Valley in the peak year 2000. That year, Bay Area firms outside Silicon Valley took in more than $10 billion



SOURCE: Author's calculations from the VentureOne database.

Figure 3.2—Total Venture Capital Investment, by Region, 1992–2001

of venture capital. This may represent a big spillover from Silicon Valley. One possibility is that too much money was chasing too few entrepreneurs in Silicon Valley and venture capitalists had to look for opportunities nearby; or, more likely, Silicon Valley simply became too crowded and expensive, making adjacent metro areas such as San Francisco and Oakland more attractive.

Table 3.1 summarizes the venture capital raised by each industry in Silicon Valley during 1992–2001. Software, communication, consumer/business services, semiconductor, electronics, information services, medical devices, and biopharmaceutical industries account for more than 96 percent of the total investment in Silicon Valley. The top three industries alone—software, communication, and consumer/business services—absorbed 63 percent of the total investment. These are also the top three industries in the nation as a whole, accounting for 59 percent of the total investment, although it is

Table 3.1

Real Venture Capital Investment, by Industry in Silicon Valley, 1992–2001

Industry	Venture Capital Raised ($ millions)[a]	% of Total	No. of Deals
Software	18,738.19	26.36	2,027
Communication	16,668.09	23.45	1,075
Consumer/business services	9,364.75	13.18	757
Semiconductor	7,038.37	9.90	632
Electronics	4,740.20	6.67	467
Information services	4,310.70	6.07	419
Medical devices	4,201.78	5.91	489
Biopharmaceutical	3,431.67	4.83	275
Retailing	1,314.42	1.85	74
Medical information services	693.58	0.98	75
Advance/special material and chemical	321.41	0.45	29
Other	108.44	0.15	14
Healthcare	66.46	0.09	7
Consumer/business products	57.20	0.08	23
Energy	18.63	0.03	5
Agriculture	—	—	1
Total	71,073.89	100	6,369

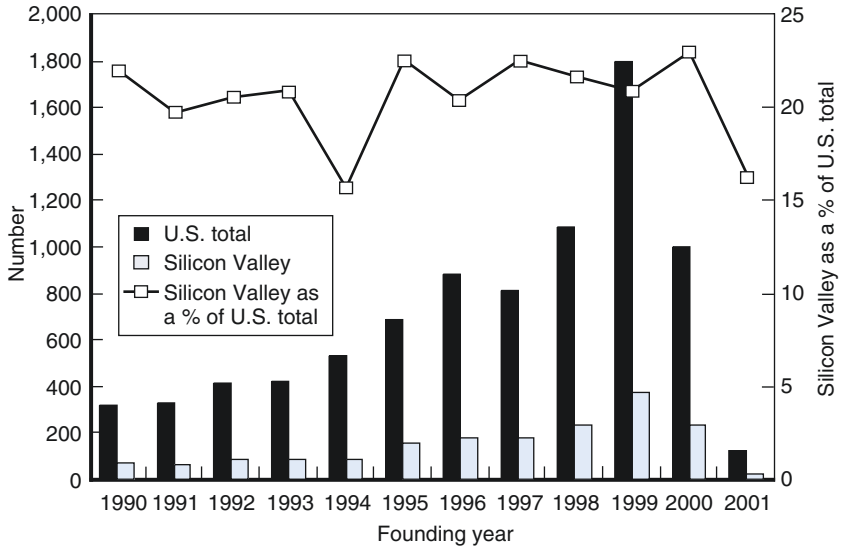
[a]In 1996 dollars.

the communication industry that tops the U.S. list. The top three industries are all very much Internet-related, clearly indicating that the 1990s were the "Internet decade" for the venture capital world. Ranked eighth in the United States, the semiconductor industry is ranked fourth in Silicon Valley. Thus, the industry for which Silicon Valley was named is still relatively well-invested. Although the biopharmaceutical industry ranks fifth in the United States, it holds only the eighth position in Silicon Valley. This is partly because the biotech industry in the Bay Area is most heavily concentrated in South San Francisco, which is outside Silicon Valley by our definition.

Firm Formation

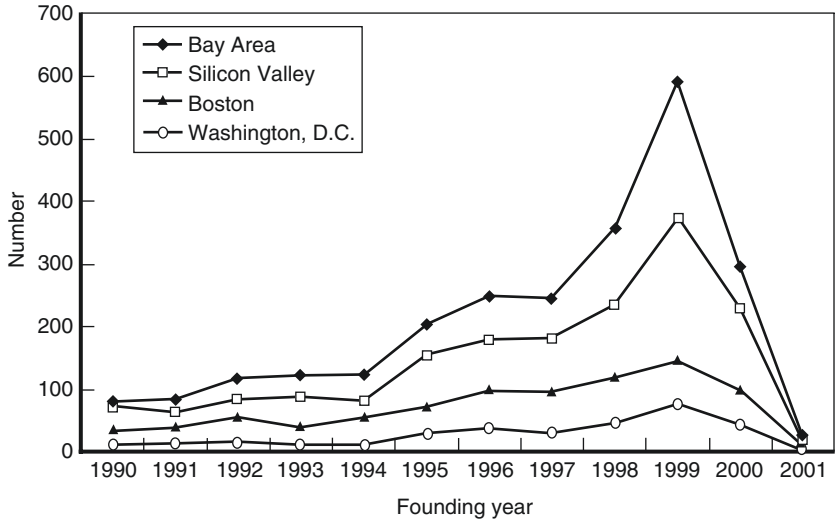
Figure 3.3 traces the trend of venture-backed start-ups by their founding year. The number of such start-ups steadily increased during the 1990s, peaking in 1999 and then declining sharply in 2000 and 2001. The decline reflects the burst of the Internet bubble and an economy heading toward a recession. Since it is possible that some start-ups founded in 2000 and 2001 will not complete their first round of financing until after 2001 and hence are not included in our data, the actual decline could be less serious than reflected in our data. The trend in Silicon Valley (where, on average, 22 percent of venture-backed start-ups are located) roughly parallels the national trend.

Figure 3.4 depicts the trend of start-up formation for different high-tech regions. Silicon Valley substantially outperformed the Boston and Washington, D.C., areas, although the three regions follow quite similar trends. In Silicon Valley, 84 start-ups founded in 1994 were financed by venture capital; the number steeply increased to 375 in 1999. During the same period, the number increased from 55 to 147 in the Boston area and from 12 to 77 in the Washington area. Percentagewise, the Washington area experienced a larger increase than Silicon Valley. The San Francisco Bay Area as a whole experienced intensive entrepreneurial activities in the late 1990s. During 1998–1999, the peak years of the Internet boom, more venture-backed start-ups were founded in the Bay Area than in the Boston area, even when excluding Silicon Valley from the Bay Area.



SOURCE: Author's calculations from the VentureOne database.

Figure 3.3—Venture-Backed Start-Ups, 1990–2001

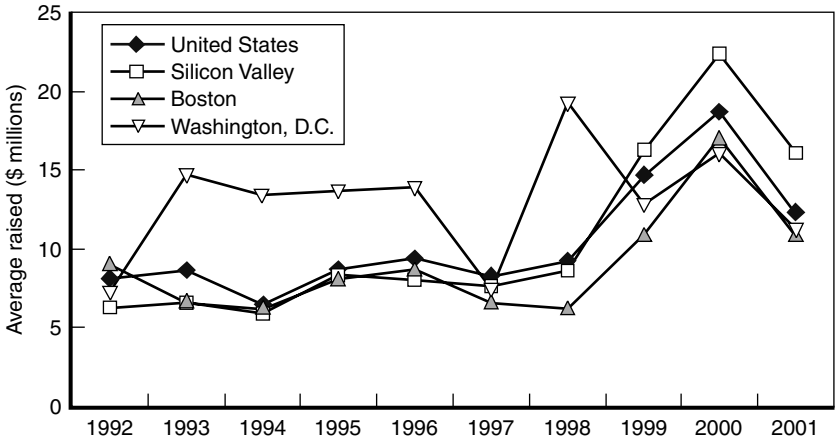


SOURCE: Author's calculations from the VentureOne database.

Figure 3.4—Venture-Backed Start-Ups, by Region, 1990–2001

Although so many venture-backed start-ups were founded in the late 1990s, entrepreneurs faced less-stringent capital constraints. The bull market in stocks and the enormous successes of early Internet-related start-ups attracted a large amount of money into the venture capital industry. As Figure 3.5 shows, start-ups founded in the late 1990s were much more generously financed than previous cohorts. In Silicon Valley, the average amount of venture capital per deal in 1992 was $6.33 million. By 1998, the average amount had climbed to $8.64 million. In 1999 and 2000, abundant venture capital showered on Silicon Valley: The average amount per deal jumped to $16.24 million in 1999 and further shot up to $22.34 million in 2000. Even in late 2001, when Silicon Valley had entered a deep recession, the venture capital industry still found itself in a situation of "too much money chasing too few ideas." In the end, entrepreneurial ideas were exhausted, not the venture capital. In 2002, many venture capital funds had to downsize and return committed cash to investors because of lack of good opportunities ("The VCs Don't Want Your Money Anymore," July 29, 2002).

Average venture capital per deal follows a similar trend in the Boston and San Francisco Bay areas. In the Boston area, the average amount dramatically increased from $6.25 million in 1998 to $18.41 million in

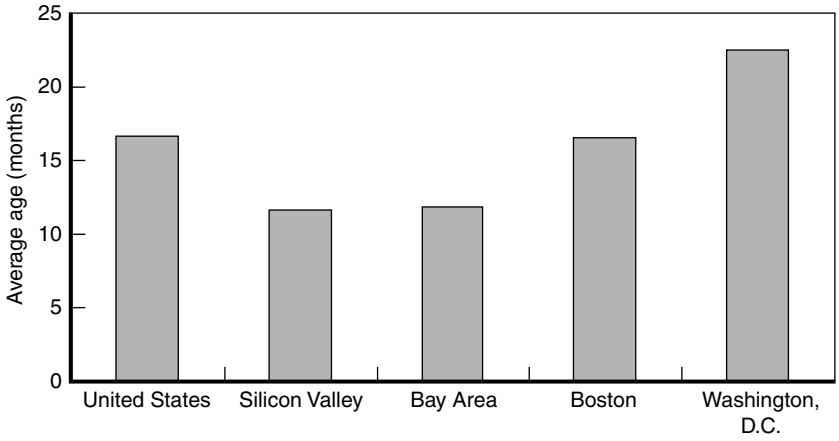


SOURCE: Author's calculations from the VentureOne database.

Figure 3.5—Average Amount of Venture Capital Raised per Deal, 1992–2001

2000. The trend in Washington, D.C., is different. In 1999 and 2000, while venture capital deals were getting fat in Silicon Valley and Boston, they were shrinking in Washington, D.C. Also interesting to note is that the average amount of venture capital per deal was considerably higher in Washington, D.C., than in other areas during 1993–1996 and 1998. For example, in 1993, 1994, and 1998, the average in Washington, D.C., is at least 100 percent higher than in Silicon Valley or Boston. A closer look at the data for the Washington, D.C., area reveals that during 1993–1996 and 1998 a disproportionately large share of venture capital was invested in the communication and healthcare industries, with both tending to acquire extremely big deals.

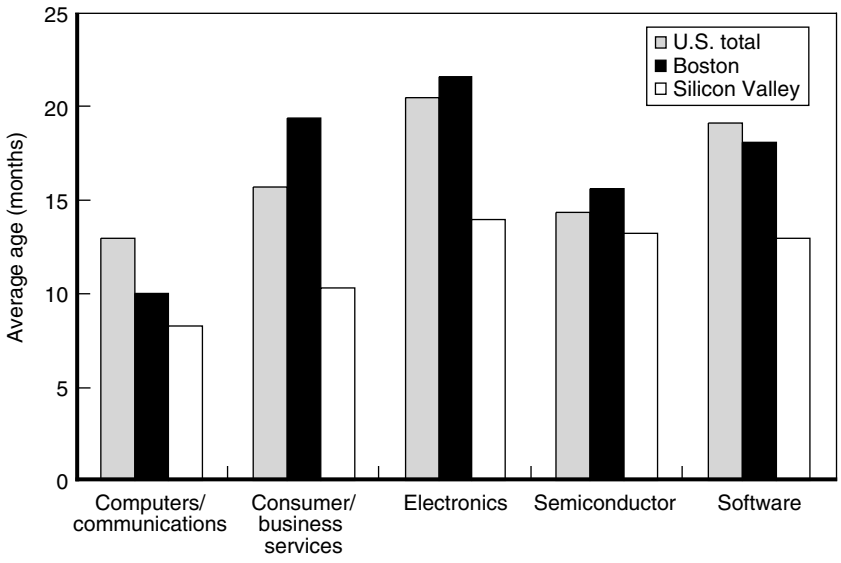
How quickly start-ups are able to obtain venture capital is also an indicator of the availability of capital in a region. We calculated the average span of time between the founding date of a start-up and the closing date of its first round of financing. Figure 3.6 shows that Silicon Valley firms are financed more quickly than firms elsewhere. In Silicon Valley, start-ups on average have raised their first round of venture capital at the age of 11.59 months. For the whole Bay Area, the average age is 11.86 months, only slightly higher than in Silicon Valley. The number is 16.58 for Boston and 16.62 for the nation as a whole. In Washington, D.C., it takes 22.54 months to close the first round of financing.



SOURCE: Author's calculations from the VentureOne database.

Figure 3.6—Average Start-Up Age at First-Round Financing

One naturally wonders whether Silicon Valley's time-efficiency is due to its specific industry composition, since the time needed for venture capital financing may be inherently different from one industry to another. Figure 3.7 compares average firm age at the first round of venture capital financing in Silicon Valley with the national average and the Boston area average within each industry. These five industries are the top five in Silicon Valley, accounting for 80 percent of its venture capital investment. Clearly, in each industry, firms in Silicon Valley are financed more quickly. For example, Silicon Valley start-ups in the software industry can have their first rounds of venture capital in place six months sooner than Boston start-ups in the same industry. In the electronics industry, the time advantage is 7.6 months. In consumer or business services, firms in Boston are on average 19.4 months old when their first round of venture financing is completed; those in Silicon Valley are only 10.3 months old. In fact, in 14 out of 16 industry segments, Silicon Valley firms take shorter time to get venture capital



SOURCE: Author's calculations from the VentureOne database.

Figure 3.7—Average Start-Up Age at First-Round Financing, by Industry

than both the national average and the average time in Boston. The two exceptions are the healthcare industry and "other," in which only six start-ups in Silicon Valley got financed during 1992–2001.

Several possible reasons may explain the promptness of the venture capital financing in Silicon Valley: (1) The well-developed venture capital industry in the region allows start-ups to find financing locally and hence speeds up the process; (2) the well-connected business networks in Silicon Valley enable entrepreneurs to find venture capitalists (or the other way around) more quickly; or simply (3) venture capitalists in Silicon Valley work differently from their counterparts elsewhere.

Start-ups in Silicon Valley naturally enjoy some advantages because of the abundance of local capital. It is well known that venture capital firms tend to finance local start-ups, so that they can closely monitor their performance and provide management guidance or assistance if needed. Silicon Valley has the world's largest venture capital cluster. Thus, firm founders in Silicon Valley have relatively easy access to capital. However, a large venture capital industry does not seem to fully explain quick venture capital finance. For example, the Seattle area has a much smaller venture capital industry than the Boston area. In fact, Boston is undoubtedly the number two venture capital cluster in the world. According to VentureOne's *Venture Capital Sourcebook* (2001), Massachusetts has 94 venture capital firms and Washington state has only 26. During 1992–2001, venture capital investment in the Boston area amounted to $31.1 billion; that number is only $10.1 billion for Seattle. However, in spite of the significant size differences in these venture capital industries, start-ups in Seattle received faster venture capital financing than those in the Boston area (16.2 months compared to 16.6 months). Thus, the proximity to considerable capital does not guarantee quick access.

Silicon Valley's risk-tolerating culture might be the real reason for the quick venture capital financing in the region. After interviewing individuals who had worked in both the Boston area and Silicon Valley, Saxenian (1994) observed that "East Coast venture capitalists were more formal and conservative in their investment strategies." The interviewees' experiences in the two regions help us understand the cultural difference. An entrepreneur in Silicon Valley told Saxenian,

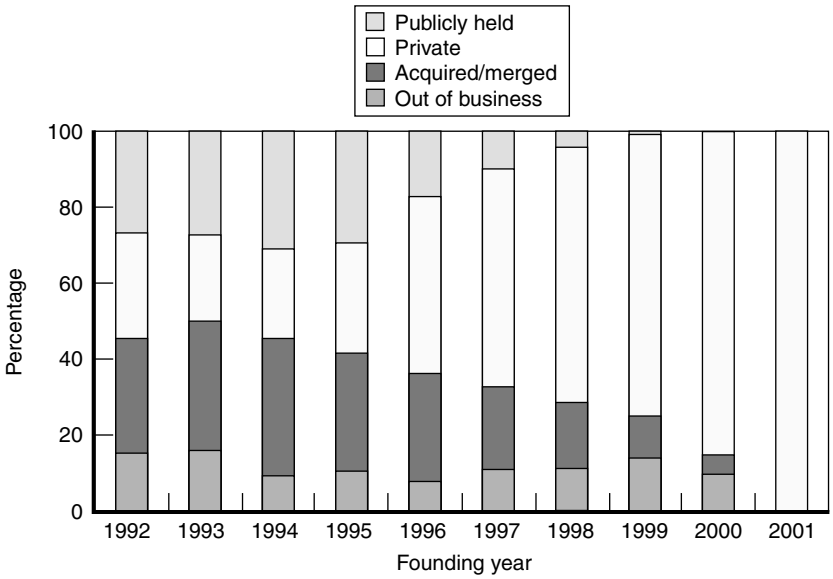
"When I started Convergent [Technologies], I got commitments for $2.5 million in 20 minutes from three people over lunch who saw me write the business plan on the back of a napkin. They believed in me. In Boston, you can't do that. It's much more formal." Another businessman says, "There is no real venture capital in Massachusetts. The venture capital community is a bunch of very conservative bankers. They are radically different from the venture capitalists in Silicon Valley, who have all been operational people in companies. Unless you've proven yourself a hundred times over, you'll never get any money" (Saxenian, 1994). Although those comments were referring to the situation in the 1980s, it is likely that Silicon Valley preserved such cultural advantage in the 1990s.

Whatever the reasons, quick financing probably gave entrepreneurs in Silicon Valley a head start over those in other regions. In the fast-moving high-tech sector, a year means a lifetime. And therefore, facilitated by local venture capital firms, innovative start-ups in Silicon Valley may enjoy some first-mover's advantages.

Ownership Status and Profitability

The VentureOne data have specific variables indicating a firm's business status and ownership status. In particular, we know with certainty whether a firm went out of business or whether it merged with another firm; we do not have to infer such events from other variables, as with the NETS data. This section focuses on ownership changes and the economic performance of venture-backed start-ups.

A general impression about venture capital investment is that it is very risky. However, this is not reflected in the disbanding rate of venture-backed firms. Figure 3.8 depicts the ownership status of such firms in Silicon Valley as of the fourth quarter of 2001. In each cohort of Silicon Valley start-ups, those that have gone out of business never amount to more than 16 percent of the total. It seems that if a start-up can survive the first two years, it is very likely to succeed. As time goes by, more and more start-ups are acquired by or merged with other firms. About one-third of start-ups change ownership through merger and acquisition (M&A) before they are ten years old. This is a much higher percentage than we found in the NETS data for all the start-ups in the



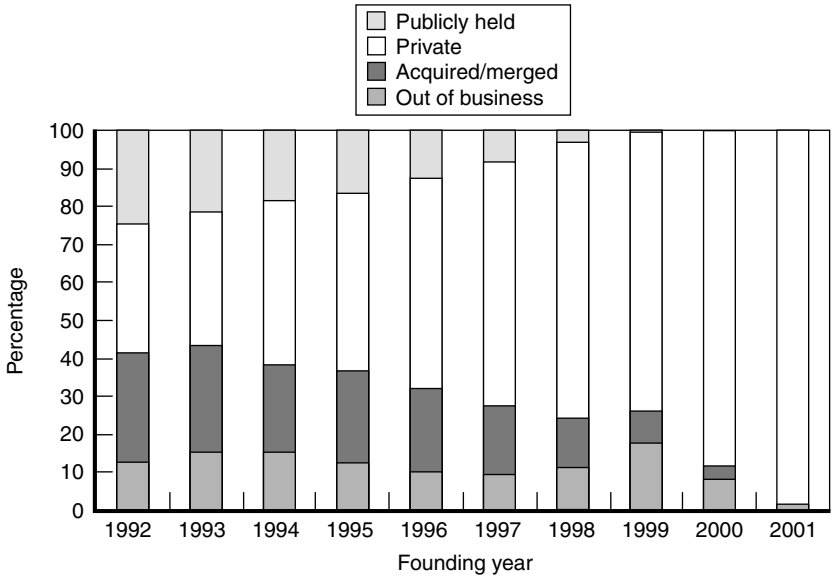
SOURCE: Author's calculations from the VentureOne database.

Figure 3.8—Ownership Status of Venture-Backed Start-Ups in Silicon Valley, 2001

preceding chapter, which suggests that start-ups that are not venture-backed are much less likely to be acquired. Many start-ups will become publicly held through IPOs (Initial Public Offerings). In Silicon Valley, nearly 30 percent of venture-backed start-ups founded before 1995 had gone public by the end of 2001. IPOs and M&As provide channels for venture capitalists to exit and pay back their investors. Some start-ups remain privately held, but that proportion is declining over time.

Figure 3.9 presents the ownership status of all venture-backed start-ups in the United States. The overall picture is similar to what we see in Silicon Valley: The disbanding rate stabilizes after two years, more and more start-ups go through M&A or IPO over time, and the number of private firms declines with time.

It is also interesting to compare the ownership outcomes of Silicon Valley start-ups with the U.S. average. In each panel in Figure 3.10, a positive value means the examined proportion in Silicon Valley is higher

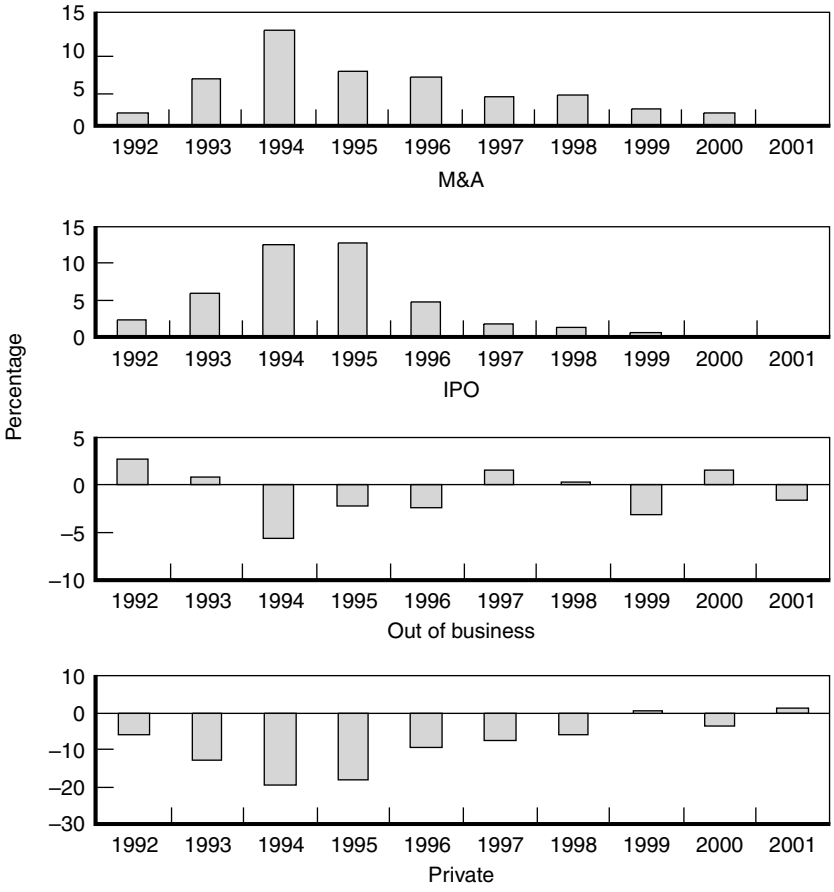


SOURCE: Author's calculations from the VentureOne database.

Figure 3.9—Ownership Status of Venture-Backed Start-Ups in the United States, 2001

than the national average. As the figures show, venture-backed start-ups in Silicon Valley are more likely to be acquired by or merged with other firms. The proportion of M&A is consistently higher than the national average for every cohort of start-ups. For example, M&A activities among start-ups founded in Silicon Valley in each year from 1993 to 1996 are at least 6 percent higher than the U.S. average. In the 1994 cohort, 36 percent of Silicon Valley start-ups went through M&A, compared to only 23 percent of the U.S. total.

Generally speaking, M&A activities are more common in high-tech industries than in other sectors. According to Mergerstat's industry report, 49 industries completed 7,518 M&A deals in 2002. The software industry alone accounted for 1,347 deals, 18 percent of the total. If we include computer hardware, communications, electronics, drugs, health services, and aerospace and defense, the seven high-tech industries account for nearly one-third of the total M&A deals. This is a



SOURCE: Author's calculations from the VentureOne database.

Figure 3.10—Differences in Ownership Status in Each Cohort of Venture-Backed Start-Ups: Silicon Valley Compared to the United States

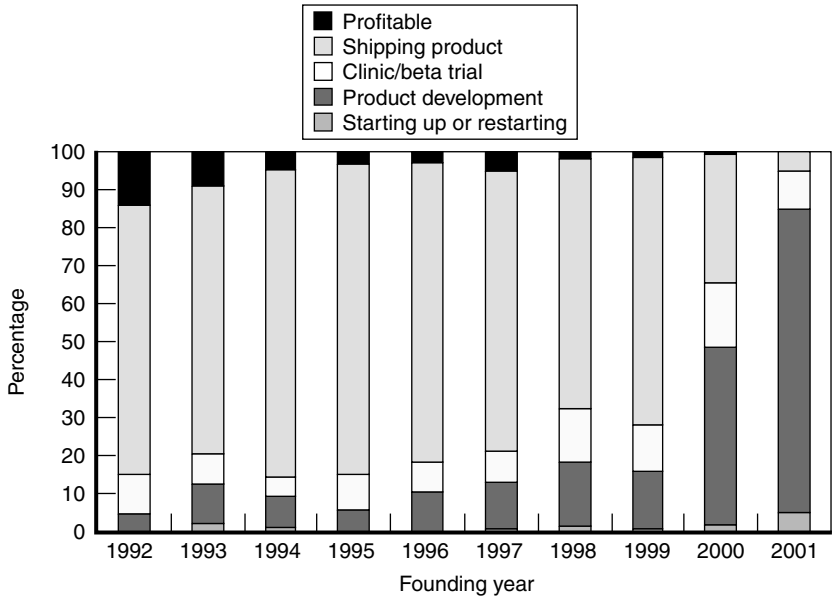
very high fraction given that even a much more broadly defined high-tech sector produces less than 11 percent of the U.S. gross domestic product (GDP) (DeVol, 1999). M&A is more active in the high-tech sector for several reasons. On the one hand, for many start-up founders, being bought out is a major avenue to the aspired financial success; at the same time, M&A provides an exit channel by which venture capitalists collect the return on their investments. On the other hand, many

established companies in the high-tech sector have incentives to acquire start-ups. The most renowned example is Cisco, which has bought 76 high-tech start-ups since 1993. In fact, Cisco's practice is so successful that it coined a new term: acquisition and development (A&D). An established company's typical motivations for buying start-ups include acquiring a technology faster than through internal development, buying market share and presence, and buying talented people (Paulson, 2001).

Two possible reasons may explain the fact that a higher proportion of Silicon Valley start-ups exit by M&A. First, Silicon Valley is no doubt the largest cluster of successful high-tech companies in the nation, all of which are potential buyers of young start-up firms. Being close to giants raises the possibility of being acquired. Second, Silicon Valley has probably the best developed networks that service the high-tech sector, including investment banks, venture capital firms, law firms, accountants, and consultants. They are all matchmakers that help form M&A deals.

Compared to the U.S. average, Silicon Valley venture-backed start-ups are also more likely to go public. This is true for every cohort. The difference is especially striking for start-ups founded before 1996. Among the 2,058 start-ups founded in the United States during 1992–1995, 403, or 20 percent of the total, had gone public by the end of 2001. In Silicon Valley, however, 118 out of 412 start-ups, or 29 percent of the total, founded in the same period were traded on the stock market by late 2001. For those founded in 1994 and 1995, the IPO rate is 12 percent higher in Silicon Valley. These two years inaugurated the era of the Internet revolution. Venture-backed start-ups in these cohorts include high-profile pioneers such as eBay, Netscape, and Yahoo.

Figures 3.11 and 3.12 depict the business status of venture-backed start-ups in Silicon Valley and the nation as a whole, given that they were not disbanded. In general, only a small proportion of venture-backed start-ups founded from 1992 to 2001 were showing a profit in the fourth quarter of 2001. The older a start-up, the more likely it is profitable. However, even among the earliest cohort, those founded in 1992, less than 14 percent in Silicon Valley and less than 20 percent in the nation were making a profit in 2001. A majority of the start-ups less than two years old were still developing or testing products.

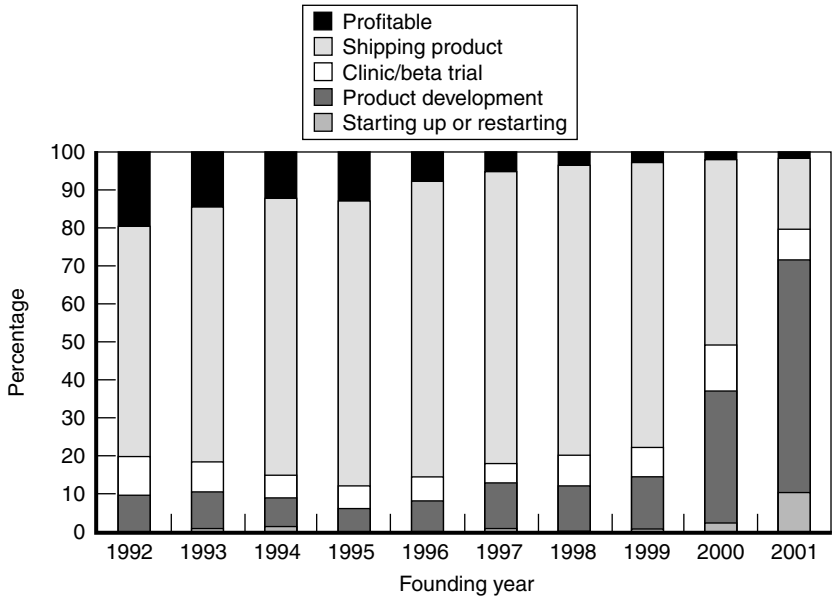


SOURCE: Author's calculations from the VentureOne database.

Figure 3.11—Business Status of Venture-Backed Start-Ups in Silicon Valley, 2001

The proportion of profitable start-ups in Silicon Valley is lower than the national average in every cohort. For cohorts founded before 1995, the proportion of profitable start-ups in the United States is always at least 5 percent higher than the proportion in the valley. Moreover, start-ups in Silicon Valley are more likely to be in the product development or testing stages than the U.S. average. Among every cohort founded after 1995, Silicon Valley has a higher percentage of such firms. Given that Silicon Valley houses about one-fifth of the venture-backed start-ups in the nation, the difference between Silicon Valley and the rest of nation should be much more significant.

This difference and the fact that start-ups in Silicon Valley have quick access to venture capital seem to suggest that the venture capital investments in the valley bear more risks than those in the rest of the United States. On the one hand, venture capitalists in Silicon Valley may have bet on many "bad" ideas and will never profit from them; on



SOURCE: Author's calculations from the VentureOne database.

Figure 3.12—Business Status of Venture-Backed Start-Ups in the United States, 2001

the other hand, they may have put money into very long term deals that will take many years to reach profitability. Neither of these is necessarily a bad strategy. In venture capital investment, the returns from a few superstar deals are usually more than enough to cover the money lost in many bad deals. The venture capitalists in Silicon Valley may have acted quickly to take the first mover's advantage in producing superstars such as Yahoo and Netscape at the cost of investing in many bad deals. In the end, although fewer of the start-ups make profits, the venture capitalists' returns from Silicon Valley investments may not be below the national average.

Spinoffs

Who founds high-tech start-ups? One group of entrepreneurs who have attracted researchers' attention is previous employees of incumbent firms. In the high-tech sector, employees sometimes leave their

employers and start their own firms in the same industry, which are called spinoffs. For example, many firms in the semiconductor industry trace their origin to a successful firm in the early years of the industry: Fairchild Semiconductor. The long list of "Fairchildren" includes such prestigious trade names as Intel, National Semiconductor, Advanced Micro Devices, Cypress, Linear Technology, and Xilinix, among others.

Spinoffs could emerge for various reasons (Klepper, 2001). For example, employees may wish to capitalize on important discoveries they make while working for a particular firm. However, it is often impossible for them to contract with their employers to commercialize the discoveries, so they start their own firms. In other cases, successful incumbent firms may have difficulties evaluating and implementing certain types of innovations, which gives individual employees opportunities to pursue such innovations by themselves. A classic example is Apple Computers' cofounder Stephen Wozniak, who used to work for Hewlett-Packard. His design of a personal computer gained no appreciation from senior engineers, so he eventually gave up on his employer and teamed up with Steve Jobs, and the two built their own computers out of a start-up in a garage (Freiberger and Swaine, 2000).

The effects of spinoffs are debatable. If employees profit from innovations they make at their previous employers, incumbent firms will have less incentive to spend on R&D. As a consequence, the whole industry may lose out to international competition, such as that faced by the U.S. semiconductor industry. On the other hand, one may argue that spinoffs provide a vehicle for knowledge transfer and hence accelerate innovation.

In her renowned study of Silicon Valley and Route 128 in the Boston area, Saxenian (1994) contends that Silicon Valley enjoys a "regional advantage" partly because its culture and institutions encourage employees to move from one firm to another. In particular, employees in Silicon Valley feel free to transfer from established firms to start-ups. This so-called "high-velocity" labor market enables knowledge gained from one firm to quickly spill over to other firms. Since knowledge circulates among a collective learning network instead of traveling in one direction, all firms benefit from this phenomenon. Saxenian argues that established firms in the Boston area, on the contrary, tend to endorse a

more inward-looking culture, which encourages loyalty to employers rather than job mobility. In the Boston area, climbing the promotion ladder within a firm is more socially acceptable than taking the risk of starting one's own business. According to Saxenian, these differential approaches provide an explanation of why Silicon Valley has overtaken the Boston area as the leading high-tech center in the country.

Gilson (1999), a law professor at Stanford, further proposed an account of the differential business cultures between Silicon Valley and Route 128. He argued that it is the different legal infrastructures in California and Massachusetts—particularly the enforceability of postemployment covenants not to compete—that make the difference. The so-called "covenants not to compete" are contractual agreements between employees and employers in which the employee promises not to compete with the employer for a certain period of time within a specific geographic area in case the employment relationship terminates. Generally, Massachusetts' courts have enforced such covenants to protect trade secrets, confidential data, or the employer's good will. Under California law, such covenants are not enforceable. According to section 16600 of California Business and Professions Code, "every contract by which anyone is restrained from engaging in a lawful profession, trade, or business of any kind is to that extent void." California courts have consistently referred to this stipulation to prohibit covenants not to compete. Employees in Silicon Valley know that they can leave current employers and found competing start-ups or join other firms in the same business; employers know that they cannot prevent such things from happening. As a result, employers in Silicon Valley adopt an approach that emphasizes both cooperation and competition.

Both Saxenian and Gilson discuss Silicon Valley's high-velocity employment using anecdotal evidence, because of a lack of empirical data. It has yet to be verified with empirical data whether established firms in Silicon Valley indeed have more spinoffs.

To resolve this issue, we matched VentureOne's founder information with firm-level data, so that we could identify where an entrepreneur founded his or her firm. We extracted two groups of venture-backed entrepreneurs by firm location: Silicon Valley and Boston. Using the biographic information of firm founders, we were able to identify which

companies a person had ever worked for. If an entrepreneur ever worked for a company or a university, we counted him or her as an "employee founder" from that company or university and the start-up as a "spinoff start-up" from that company or university. The number of employee founders does not necessarily agree with the number of spinoff start-ups. On the one hand, some employee founders turned into "serial entrepreneurs," founding two or more start-ups; on the other hand, two or more employees may cofound a single start-up.

Table 3.2 compares spinoffs from leading firms and universities in Silicon Valley and the Boston area.[1] Indeed, leading firms in Silicon Valley significantly outperformed their counterparts in the Boston area in terms of producing entrepreneurs. Raytheon and DEC are probably the two most prestigious names in the Boston area's high-tech history. DEC

Table 3.2

Number of Spinoffs from Leading Institutions in Silicon Valley and the Boston Area

	Silicon Valley[a]			Boston Area[b]	
	Employee Founders	Spinoff Start-Ups		Employee Founders	Spinoff Start-Ups
Leading Companies					
Apple	94	71	Data General	13	13
Cisco	41	35	DEC	52	41
HP	117	99	EMC	9	6
Intel	76	68	Lotus	29	26
Oracle	73	57	Prime	5	5
SGI	50	37	Raytheon	7	7
Sun	101	79	Wang	11	11
IBM	82	77	IBM	23	23
Leading Universities					
Stanford	71	64	MIT	74	63
UC Berkeley	20	20	Harvard	32	31

[a]Founder sample size: 2,492.

[b]Founder sample size: 1,157.

[1]The VentureOne data cover only start-up founders who have ever been funded by venture capital since 1992. Therefore, no number in Table 3.2 should be interpreted as the total number of spinoffs in the firm's (or university's) history.

scored the highest in the Boston area with 52 employee founders; Raytheon, the largest employer in Boston's high-tech sector, with about 15,000 employees locally, produced only seven entrepreneurs according to the VentureOne data.[2] Together, DEC and Raytheon spun off 48 venture-backed start-ups, only about half of the 99 spinoffs from Hewlett-Packard. Sun Microsystems, a 20-year-old company in Silicon Valley, has seen more than 100 previous employees become venture-backed entrepreneurs; yet EMC, another big name in the Boston area, founded three years earlier than Sun, had only nine employees who founded start-ups. Apple Computers and Lotus Development Corporation are no doubt two of the most successful pioneers in the early years of the personal computer era. Apple in Silicon Valley has spun off 71 venture-backed start-ups, whereas Lotus in the Boston area lags far behind with only 26 spinoffs. Boston's Data General, Prime Computer, and Wang Laboratory all once were giants in the minicomputer market created by DEC, but they are all dwarfs in terms of spinoffs, compared to leading firms in Silicon Valley such as Cisco, Oracle, or SGI. Even IBM, the New York–based high-tech conglomerate that has a presence in both areas, has many more spinoffs in Silicon Valley.

However, a comparison of the leading universities in the two areas tells a different story. In this case, Boston is doing as well as Silicon Valley, if not better. Among the 1,157 venture-backed entrepreneurs in Boston, 74 have worked at MIT; yet only 71 out of the 2,492 entrepreneurs in Silicon Valley have ever been Stanford employees. Harvard also comes in better than Berkeley, 32 to 20. Notice, we consider here only entrepreneurs who have ever worked at those universities. The number of firm founders who graduated from those universities is a natural alternative measure. Unfortunately, the VentureOne data do not provide such information. Table 3.2 suggests that leading firms in Silicon Valley have spun off more entrepreneurs than those in the Boston area; however, leading universities in Boston have more employees who commercialize their innovations by founding

[2]Raytheon's role as a defense contractor may have placed some restrictions on potential employee founders.

start-ups. Whether it is the culture/institutions or the legal infrastructure that enables Silicon Valley to surpass Boston in terms of employee founders and spinoffs, the big difference seems to be in the business world as opposed to academia.

Conclusion

Since 1994, Silicon Valley has consistently accounted for more than 20 percent of the total venture capital investment in the United States. Venture capital investment in Silicon Valley surged in the late 1990s. On the one hand, the increased venture capital gave a big push to entrepreneurial activities during the Internet boom; on the other hand, the size of venture capital deals during the late 1990s became much bigger. Software, communications, consumer/business services, semiconductor, and electronics industries were the most heavily invested high-tech industries in the region. Silicon Valley start-ups have quicker access to venture capital in almost every industry. Although the exact reasons for this quick access remain unclear, it certainly helps firms in Silicon Valley to get a head start. A preliminary examination of venture-backed firm founders in Silicon Valley and the Boston area confirms that successful firms in Silicon Valley tend to have more spinoffs than their counterparts in Boston. The difference in university spinoffs is not significant between the two regions.

4. Firm Relocation in Silicon Valley

Silicon Valley is the most renowned example of an industrial cluster. Classical economic theory teaches that a cluster is attractive to firms for multiple reasons, including a specialized labor pool, specialized inputs, proximity to customers, knowledge spillovers, and so on. For high-tech start-ups, the benefits from a cluster may also include easy access to capital and the psychological support that an entrepreneur receives from his peers and the community.

It is worth noting that high-tech start-ups and mature firms may have different locational concerns. Start-ups are more dependent on outside resources at the developing stage, and, as newcomers, they suffer from lack of credibility. For these reasons, the entrepreneur's local connections and his familiarity with local institutions have a big effect on the formation and growth of a start-up. Therefore, we observe two empirical regularities: (1) high-tech firm founders are usually engineers who have working experiences in industrial clusters, where local culture and institutions are favorable to new firms, and (2) high-tech firm founders rarely move outside the immediate area when they decide to start new firms (Cooper and Folta, 2000). Thus, start-ups are more likely to emerge in clusters such as Silicon Valley than in other places.

However, mature firms are more likely to follow routinized operations and are more concerned about the costs of doing business. An industrial cluster, once established, tends to face high demand for labor and land and also the overuse of infrastructure. This drives up operating costs for firms in the cluster. At the same time, the overloaded infrastructure may lower the quality of life in the cluster. For these reasons, mature firms may choose to set up branches elsewhere rather than in the cluster. When the costs of doing business are high enough in a cluster, mature firms themselves may consider relocating.

Silicon Valley and the San Francisco Bay Area in general have long been notorious for the high costs of living and doing business. This has usually been recognized as a threat to economic growth in the area.[1] High costs may deter firm formation in Silicon Valley and may push mature firms away so that the region will not reap the fruit it grows. Our analysis in the previous chapters has shown that entrepreneurial activities were intensive in Silicon Valley during the past decade. Entrepreneurs were probably driving up costs even higher, rather than being scared away by them. In this chapter, we investigate whether mature firms tend to leave Silicon Valley and, if they do, how large the effect is.

Although start-ups differ from mature firms, high-tech firms and nontech firms may weigh factors differently when they consider their locations. High-tech firms are in knowledge-intensive businesses. Therefore, they care more about the availability of a well-educated labor pool and knowledge spillovers from their competitors and partners. In contrast, nontech firms might be more responsive to land price, transportation cost, tax burden, and so on. Silicon Valley experienced an Internet revolution in the high-tech sector during the 1990s. The intensive entrepreneurial activities in that period raise the question of whether the booming high-tech sector crowded out nontech firms. In this chapter, we shed some light on this issue.

High-Tech and Nontech Relocation

Throughout this chapter, firm relocation is measured by locational change at the establishment level. Remember, an establishment is a business or industrial unit at a single physical location. If a firm has multiple establishments, we track each single establishment rather than the firm as a whole. An establishment has moved if its reported address has changed. We do not consider acquisitions that result in ownership changes but not physical movements of establishments.

Table 4.1 reveals some interesting facts. First, establishments in Silicon Valley do move. During 1990–2001, 25,485 out of 217,169 establishments changed addresses at least once. Some establishments

[1]One could also argue that the high cost of doing business is not a threat but a sign of Silicon Valley's economic health.

Table 4.1

Relocation of Establishments in Silicon Valley, 1990–2001

	High-Tech Sector		Nontech Sector	
	No. of Establishments	% in Total	No. of Establishments	% in Total
Never moved	42,354	82.44	149,330	90.07
Relocated out	1,490	2.90	3,111	1.88
Relocated in	894	1.74	1,834	1.10
Relocated within Silicon Valley	6,637	12.92	11,519	6.95
Total	51,375	100	165,794	100

moved into the area, some moved out, and still others moved around within Silicon Valley. For the purpose of our study, we care more about those establishments moving in and out.

Second, high-tech establishments are more likely to move than nontech establishments. Nearly 18 percent of high-tech establishments moved whereas only about 10 percent of nontech establishments relocated. Two possible reasons explain this difference. On the one hand, high-tech firms by their very nature are more mobile. Many high-tech firms, especially those in software and research, use portable equipment and occupy little land space. Nontech sectors include establishments in agriculture, forestry, mining, utilities, and government branches and agencies, which are all somewhat attached to well-defined territories. Establishments in nontech manufacturing and services, although generally not fixed to their locations, may have bulky equipment or need large land space, and thus face high moving costs. On the other hand, high-tech establishments tend to develop fast and quickly outgrow their office space. So moving into new office buildings could be more common among them.

Third, establishments are more likely to relocate within Silicon Valley. Among all establishments that moved, 79.8 percent remained within Silicon Valley.

Fourth, establishments relocating out of Silicon Valley outnumber those moving in. This is true in both the high-tech and nontech sectors. It seems consistent with our intuition that the high costs of doing business may push businesses away from Silicon Valley.

Tables 4.2 and 4.3 list the top destination states and cities for establishments that moved out of Silicon Valley. It seems that distance is a very important factor in business relocation. A majority of the establishments moving out of Silicon Valley remained in California—75.6 percent of high-tech establishments and 84.6 percent of nontech establishments. Those that moved to other states tended to choose

Table 4.2

Top Ten Destination States for Establishments Relocating Out of Silicon Valley, 1990–2001

	High-Tech Sector			Nontech Sector		
	Destination State	No. of Establishments	No. of Employees	Destination State	No. of Establishments	No. of Employees
1	California	1,126	12,700	California	2,631	27,750
2	Texas	34	1,570	Oregon	56	275
3	Nevada	32	354	Arizona	47	348
4	Oregon	30	355	Nevada	40	547
5	Colorado	21	1,404	Washington	39	146
6	Washington	21	187	Texas	36	1,941
7	Massachusetts	20	932	Colorado	33	2,075
8	Arizona	20	208	Florida	24	303
9	Florida	19	1,944	Illinois	20	612
10	New York	18	1,272	Utah	18	229

Table 4.3

Top Ten Destination Cities for Establishments Relocating Out of Silicon Valley, 1990–2001

	High-Tech Sector			Nontech Sector		
	Destination City	No. of Establishments	No. of Employees	Destination City	No. of Establishments	No. of Employees
1	San Francisco	148	1,744	Hayward	286	3,414
2	Hayward	88	1,211	Burlingame	219	2,968
3	Burlingame	84	871	San Francisco	205	2,312
4	Pleasanton	75	1,097	Pleasanton	131	2,998
5	Santa Cruz	34	207	Livermore	78	1,360
6	San Ramon	28	129	Santa Cruz	73	354
7	Oakland	27	411	San Leandro	62	498
8	South San Francisco	26	650	Oakland South San Francisco	55 49	490 828
9	Livermore	21	209	Sacramento	43	544
10	San Diego	16	542			

states in the west. Arizona, Colorado, Nevada, Oregon, Texas, and Washington are among the top ten destination states for both high-tech and nontech establishments. It is interesting to note that Florida appears on both lists, probably for its California-like warm weather. East Coast states Massachusetts and New York are among the top ten destination states for high-tech establishments, possibly because both states have strong high-tech sectors; neither appears on the list for nontech establishments.

The importance of distance is also reflected in the lists of top destination cities. San Francisco Bay Area cities occupy the top nine spots for both high-tech and nontech establishments. San Francisco, Hayward, Burlingame, and Pleasanton are the top four on both lists. Among those that leave the Bay Area, high-tech establishments tend to favor San Diego whereas nontech establishments are likely to go to Sacramento.

Tables 4.4 and 4.5 list the top origin states and cities for establishments moving into Silicon Valley. A majority of the establishments moving into Silicon Valley—76.6 percent of high-tech establishments and 89.7 percent of nontech establishments—are from other places in California. Among high-tech establishments moving in from outside California, distance does not seem to be the only major determining factor. East Coast states Massachusetts, New York, and New Jersey each had more establishments that moved to Silicon Valley than California's neighbors such as Arizona, Nevada, and Oregon. It is not surprising that Massachusetts, New York, and Texas follow California on the high-tech list because all of them have strong high-tech economies.

Although Silicon Valley is the most concentrated high-tech industrial center in the country, its nontech sectors together have more establishments and hire more employees. Thus, in Table 4.2, it is quite natural to see more nontech than high-tech establishments leaving Silicon Valley. Yet, in Table 4.4, high-tech establishments moving in from outside California outnumbered nontech establishments. It is consistent with our general impression that Silicon Valley is more attractive to high-tech than nontech firms.

Table 4.4

Top Ten Origin States for Establishments Relocating Into Silicon Valley, 1990–2001

	High-Tech Sector			Nontech Sector		
	Origin State	No. of Establishments	No. of Employees	Origin State	No. of Establishments	No. of Employees
1	California	685	13,453	California	1,645	16,420
2	Massachusetts	33	1,168	New York	19	920
3	New York	29	727	Texas	15	126
4	Texas	21	182	Washington	14	78
5	Illinois	13	148	Nevada	13	95
6	Colorado	12	440	New Jersey	13	56
7	New Jersey	12	222	Oregon	13	53
8	Oregon	8	74	Arizona	12	80
9	Pennsylvania	6	106	Florida	8	242
10	Nevada	6	69	Illinois	8	158

Table 4.5

Top Ten Origin Cities for Establishments Relocating Into Silicon Valley, 1990–2001

	High-Tech Sector			Nontech Sector		
	Origin City	No. of Establishments	No. of Employees	Origin City	No. of Establishments	No. of Employees
1	San Francisco	130	1,225	San Francisco	267	2,145
2	Burlingame	66	915	Burlingame	205	2,222
3	Hayward	48	1,306	Hayward	199	2,958
4	South San Francisco	36	353	South San Francisco	74	1,424
5	Santa Cruz	33	1,575	Oakland	54	349
6	Pleasanton	24	274	San Leandro	42	562
7	Oakland	17	902	Santa Cruz	38	190
8	San Diego	11	195	San Bruno	34	523
9	Los Angeles	11	99	Pleasanton	30	314
10	San Bruno	10	150	Los Angeles	26	235

Again, top origin cities are mostly in the San Francisco Bay Area, with San Diego and Los Angeles the two exceptions. San Francisco, Burlingame, Hayward, and South San Francisco are the top four on both the high-tech and nontech lists. Comparing Table 4.5 with Table 4.3, we see that more establishments move out of Silicon Valley to adjacent cities than move in from those cities. This is particularly true for nontech sectors, in which we see that not only more establishments but

also more employees move out of Silicon Valley to nearby cities. This seems to suggest that Silicon Valley was expanding and its economic activities spilling over into other Bay Area cities.

Table 4.6 breaks out relocating high-tech establishments by industry. During 1990–2001, 1,490 establishments moved out of Silicon Valley, which together represented 26,684 jobs; 894 establishments moved into Silicon Valley, with a total of 20,999 employees. Measured by either net establishments or net employees, the Silicon Valley economy is spilling out. In every industry, establishments moving out outnumbered those moving in. Out-moving establishments also had more employees except in two industries: In computers/communications, the net flow of employees is close to zero; in the semiconductor industry, there was a net employment inflow, although more establishments moved out. The two service industries had more moving establishments than the other high-tech industries. Yet because service establishments are generally smaller, the relocation in the computer and software industries involved more employees.

Table 4.7 summarizes firm relocation by industry group, including both high-tech and nontech industries. During 1990–2001, every sector in Silicon Valley registered a net loss because of firm relocation, measured either by total number of establishments or by total

Table 4.6

High-Tech Establishments Relocating Into and Out of Silicon Valley, by Industry, 1990–2001

	Moving Out		Moving In	
	No. of Establishments	No. of Employees	No. of Establishments	No. of Employees
Bioscience	82	2,153	51	1,510
Computers/ communications	117	5,737	86	5,740
Defense/aerospace	15	577	1	39
Environmental	17	178	12	125
Semiconductor	39	1,356	35	2,918
Software	281	7,023	186	5,278
Professional services	527	5,343	282	2,389
Innovation services	412	4,317	241	3,000
Total	1,490	26,684	894	20,999

Table 4.7

All Establishments Relocating Into and Out of Silicon Valley, by Industry Group, 1990–2001

	Moving Out		Moving In	
	No. of Establishments	No. of Employees	No. of Establishments	No. of Employees
Agriculture, forestry, and fishing	48	306	29	237
Mining	5	42	3	31
Construction	386	3,501	184	1,103
Manufacturing	796	17,769	356	13,996
Transportation, communication, and utilities	177	2,596	117	1,898
Wholesale trade	703	7,153	444	4,495
Retail trade	503	4,082	391	2,919
Finance, insurance, and real estate	346	5,984	207	1,881
Services	1,635	21,255	995	13,452
Total	4,599	62,688	2,726	40,012

employment. Altogether, establishments relocating out of Silicon Valley outnumbered those relocating in by 1,873; those moving out offered 22,676 more jobs than those moving in. The service sector, the largest sector in the Silicon Valley economy, lost the most establishments (640) and jobs (7,803). The finance, manufacturing, construction, and wholesale sectors each lost more than 2,000 jobs.

Trans-State Relocation

From the state of California's point of view, the spillover of economic activities from Silicon Valley to other Bay Area cities could be a welcome trend. However, establishments relocating out of the state may be a cause for concern. In this section, we more closely examine Silicon Valley establishments that relocated to or from other states.

Tables 4.8 and 4.9 replicate Tables 4.6 and 4.7 for establishments moving between Silicon Valley and outside California. We see similar patterns on a smaller scale in both the high-tech sector and the overall economy: Silicon Valley saw more businesses relocating out than relocating in. This is true even if we separate the high-tech sector into

Table 4.8

High-Tech Establishments Moving Between Silicon Valley and Outside California, by Industry, 1990–2001

	Moving Out		Moving In	
	No. of Establishments	No. of Employees	No. of Establishments	No. of Employees
Bioscience	27	844	12	486
Computers/communications	48	4,458	31	3,385
Defense/aerospace	3	337	0	0
Environmental	1	4	0	0
Semiconductor	16	880	11	750
Software	88	3,925	53	1,614
Professional services	83	2,208	39	264
Innovation services	98	1,328	63	1,047
Total	364	13,984	209	7,546

Table 4.9

All Establishments Moving Between Silicon Valley and Outside California, by Industry Group, 1990–2001

	Moving Out		Moving In	
	No. of Establishments	No. of Employees	No. of Establishments	No. of Employees
Agriculture, forestry, and fishing	4	9	2	5
Mining	1	2	0	0
Construction	43	153	18	57
Manufacturing	209	8,999	88	6,355
Transportation, communication, and utilities	32	680	18	189
Wholesale trade	113	1,530	71	758
Retail trade	76	476	29	163
Finance, insurance, and real estate	45	2,919	18	156
Services	321	7,766	154	2,758
Total	844	22,534	398	10,441

different industries or separate the overall economy into industry groups. It is really striking that the pattern is always the same in every subindustry (or industry group), whether we measure net flow of establishments or of employment. There is a clear pattern that Silicon Valley has been losing enterprises to other states over the past decade.

In Table 4.10, we calculate the percentage of employees moving across the state border as they relocated into or out of Silicon Valley. Of all the employees that moved, 32.1 percent did not relocate within California. The high-tech sector saw a higher percentage of interstate movement (45.2 percent) than the overall economy (32.1 percent). Except for the environmental industry, a minor industry in Silicon Valley, every high-tech industry experienced at least 32 percent employee movement one way or the other across the state border. The computers/communications industry tops the list with nearly 70 percent interstate relocation. Defense/aerospace and software also stand out with 54.7 percent and 45 percent, respectively. If we look at the overall economy with both high-tech and nontech sectors, the manufacturing sector has the highest percentage of movement between Silicon Valley and outside California (48.3 percent). At 39.1 percent, the finance sector is the only other sector with above-average trans-state movement.

We also calculate the average age of establishments moving between Silicon Valley and other states. Figure 4.1 shows that in both high-tech and nontech sectors, a higher proportion of establishments that moved out were founded before 1990 compared to those that moved into Silicon Valley from other states. Figure 4.2 compares the average age of

Table 4.10

Trans-State Relocation as a Percentage of Total Employment That Moved Into or Out of Silicon Valley, 1990–2001

Industry	%	Industry Group	%
Computers/communications	68.3	Manufacturing	48.3
Defense/aerospace	54.7	Finance, insurance, and real estate	39.1
Software	45.0	Services	30.3
Semiconductor	38.1	Wholesale trade	19.6
Bioscience	36.3	Transportation, communication,	
Innovation services	32.5	and utilities	19.3
Professional services	32.0	Retail trade	9.1
Environmental	1.3	Construction	4.6
Overall	45.2	Mining	2.7
		Agriculture, forestry, and fishing	2.6
		Overall	32.1

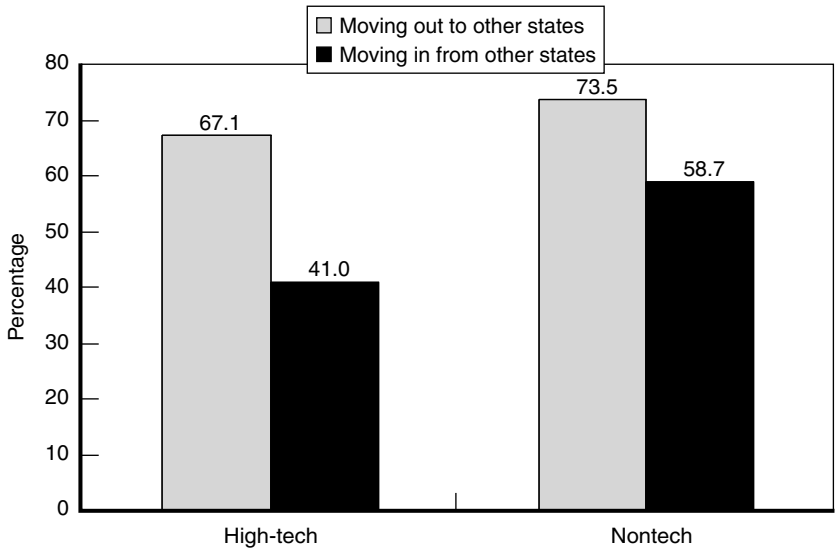


Figure 4.1—Percentage of Moving Establishments Founded Before 1990

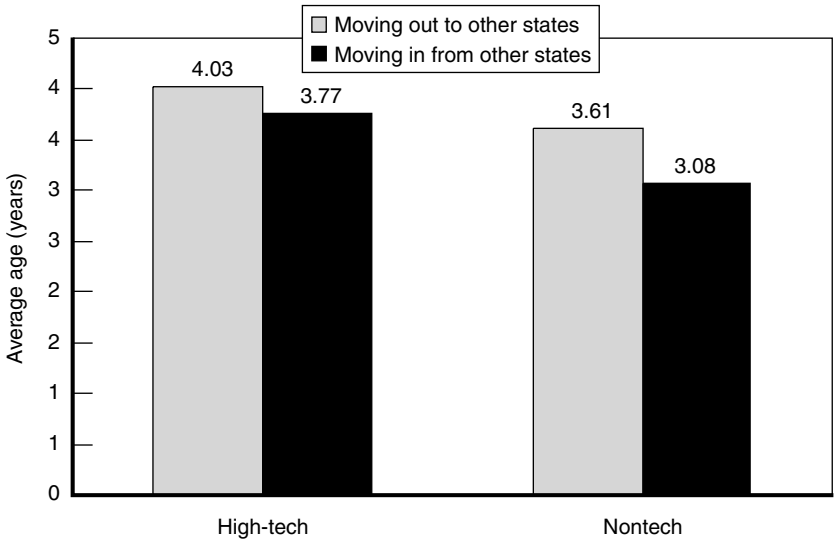


Figure 4.2—Average Age of Establishments Moving Between Silicon Valley and Other States

moving establishments founded during 1990–2000. The out-moving establishments tend to be older in both high-tech and nontech sectors, although the differences are not large.

Figure 4.3 tracks the number of jobs eliminated by establishments moving out of California and the number created by those moving to Silicon Valley from other states from 1991 to 2000. The moving activities in both directions seem to have accelerated since 1996, probably because of the Internet boom and the resulting "digital rush" during the late 1990s. The high-tech sector saw more jobs move into Silicon Valley than moved out only in 1996. Nontech sectors had a net inflow of jobs only in 1994. Overall, only the year 1996 saw a net inflow of total jobs.

We have seen a clear pattern in firm relocation between Silicon Valley and outside California. High-tech establishments, if they move, are more likely than nontech establishments to move to or from other states. In both high-tech and nontech sectors, more establishments moved out than moved in, whether measured by total number of establishments or total employment. Out-moving establishments are older. All these facts are consistent with our intuition that Silicon Valley

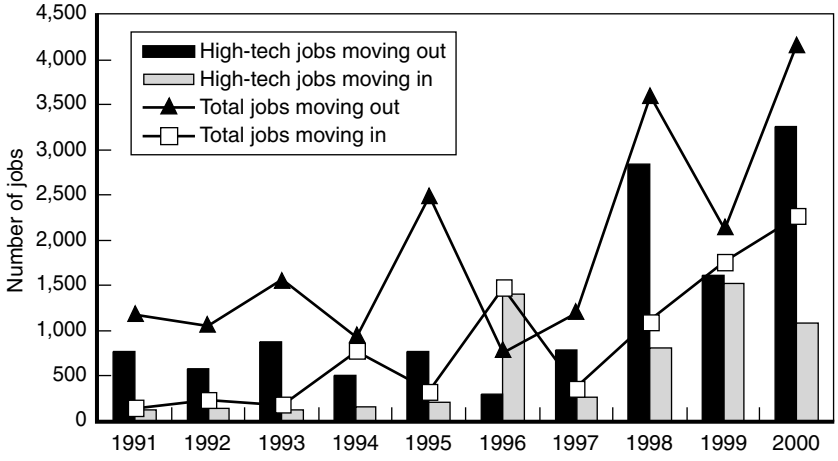


Figure 4.3—Job Movement Between Silicon Valley and Other States, 1991–2000

is attractive primarily to high-tech firms, and especially high-tech start-ups, and is losing mature businesses. A further question is whether the trend we observe is serious enough to worry policymakers and the business community.

Mobility vs. Vitality

Each year, new firms are created, offering many jobs; at the same time, some existing firms are closed and their employees are laid off. Some firms leave Silicon Valley, taking jobs away; others move into the region, bringing new employment opportunities with them. Tables 4.11 and 4.12 describe these dynamics in Silicon Valley's job market, in the high-tech sector and in the whole economy, respectively. The tables show that firm relocation has a much smaller effect on the labor market than firm birth and death.

We use two indexes to measure the dynamics in the labor market in Silicon Valley:

Rate of vitality	=	(jobs created by new establishments + jobs lost by dead establishments)/total employment;
Rate of mobility	=	(jobs offered by in-moving establishments + jobs taken away by out-moving establishments)/total employment.

Figures 4.4 and 4.5 present the rate of vitality, the rate of mobility, and the rate of interstate mobility in the Silicon Valley labor market. On average, the rate of vitality is 14.2 percent in the high-tech sector and 13.3 percent in the whole economy. The rate of mobility is only 0.8 percent in the high-tech sector and 0.7 percent in the overall economy. Compared to firm birth and death, establishment relocation has an almost negligible effect on the labor market. On average, new establishments offer 6.4 percent of Silicon Valley's high-tech jobs, and dead establishments eliminate 7.8 percent of them. The growth of existing establishments could make up the difference. At the same time, establishments that relocate out of Silicon Valley take away only 0.43 percent of its high-tech jobs, and establishments that moved into the valley offer 0.35 percent of the total high-tech jobs. If we consider the

Table 4.11

Employment in the High-Tech Sector of Silicon Valley, 1991–2000

Year	Total Employment	Total No. of Employees in New Firms	Total No. of Employees in Dead Firms	Total No. of Employees Moving Out of Silicon Valley	Total No. of Employees Moving Into Silicon Valley	Total No. of Employees Moving Out of California	Total No. of Employees Moving Into California
1991	523,496	16,487	36,997	1,796	639	764	117
1992	512,536	28,257	32,597	1,375	3,970	572	143
1993	545,575	60,895	47,182	1,607	566	882	120
1994	524,722	22,154	20,984	1,055	2,363	516	160
1995	539,885	34,910	37,649	1,532	856	774	217
1996	565,560	54,311	51,585	1,411	1,963	296	1,400
1997	588,031	40,672	38,113	1,992	2,440	790	254
1998	605,607	32,147	56,006	4,573	1,691	2,844	808
1999	606,731	25,584	46,559	3,059	2,251	1,607	1,524
2000	650,331	48,941	72,816	5,706	2,987	3,253	1,088

Table 4.12

Employment in Silicon Valley, 1991–2000

Year	Total Employment	Total No. of Employees in New Firms	Total No. of Employees in Dead Firms	Total No. of Employees Moving Out of Silicon Valley	Total No. of Employees Moving Into Silicon Valley	Total No. of Employees Moving Out of California	Total No. of Employees Moving Into California
1991	1,346,351	35,156	86,673	5,745	2,710	1,191	163
1992	1,312,856	54,468	72,909	3,656	5,814	1,075	242
1993	1,407,188	177,262	87,457	4,346	2,840	1,564	192
1994	1,380,399	54,990	90,645	2,837	4,063	933	782
1995	1,374,146	75,860	85,555	5,277	2,445	2,489	341
1996	1,395,816	102,531	119,410	3,335	3,164	764	1,482
1997	1,435,747	106,764	98,418	5,142	4,889	1,197	371
1998	1,455,318	75,548	122,619	8,711	4,032	3,586	1,109
1999	1,445,922	68,350	106,316	6,763	3,915	2,123	1,761
2000	1,511,192	107,549	140,620	9,400	5,373	4,155	2,265

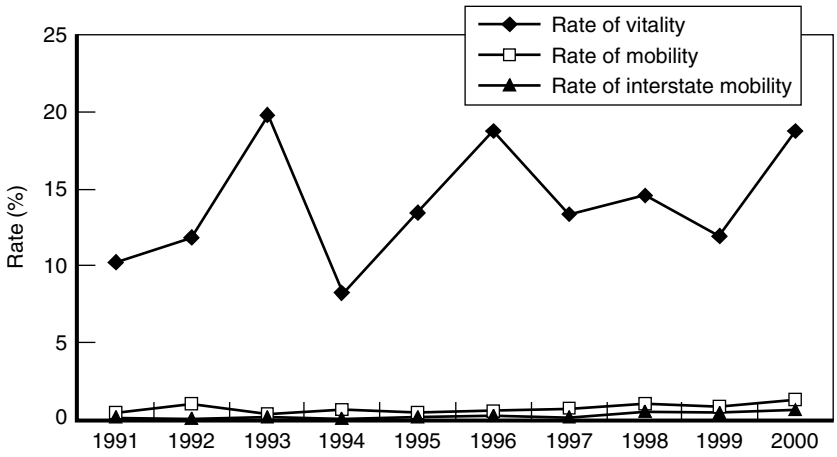


Figure 4.4—Dynamics in Silicon Valley's High-Tech Labor Market, 1991–2000

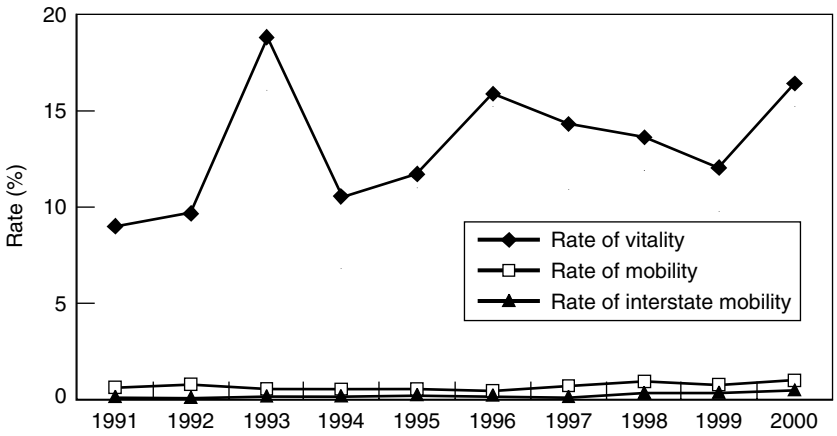


Figure 4.5—Dynamics in Silicon Valley's Labor Market, 1991–2000

nontech sectors as well, the overall Silicon Valley economy sees a little less birth, death, and relocating activities, but the relative effect of vitality and mobility is similar.

Note that in calculating the rate of vitality, we included all new establishments (i.e., some are new firms and others are new offices or

plants set up by existing firms). If we focus only on jobs created by new firms, they account for 2.6 percent of the high-tech employment and 2.1 percent of the overall employment. Again, jobs created by new firms alone are much more than enough to cover job losses by firm relocation.

We should thus conclude that although Silicon Valley is losing jobs as a result of firm relocation, the magnitude of the loss is relatively small. In other words, once firms are founded in Silicon Valley, they are very likely to stay there. A vibrant economy in Silicon Valley with intensive entrepreneurial activities and rapid growth will generate job opportunities that are more than enough to compensate for any leakage of jobs.

Relocating Out vs. Branching Out

In the preceding sections, we have examined whether firms choose to relocate out of Silicon Valley and where they go if they do move out. A related question that also concerns us is whether start-ups in Silicon Valley tend to set up branches elsewhere as they mature. Although very few establishments move to other states, many firms may choose to headquarter in Silicon Valley but to locate production or distribution capacities in other states. In such cases, California does not fully benefit from the economic growth enabled by Silicon Valley. We must recognize that some companies have an absolute need to reach out to their customers and hence have to open offices nationally or even globally. For example, software companies usually earn a large proportion of their revenue from on-site services to their customers, and thus they need to operate at locations near clusters of customers. Consider Oracle, the world's largest enterprise software company based in Silicon Valley. It has employees all over the world; in the United States alone, it has 78 offices in 76 cities in over 35 states. Another company based in Silicon Valley, Siebel Systems, which specializes in e-business application software, has employees in 31 foreign countries. At the young age of ten, Siebel has already opened 57 offices in 28 states. It makes sense for such firms to expand beyond California. However, not all high-tech firms need to be physically close to customers.

An example may shed some light on this issue. Table 4.13 shows that Intel, probably one of the most famous companies in Silicon Valley, in fact hires many more people outside California. Although it has 7,500

Table 4.13

Intel Operating Locations in the United States

City	State	No. of Employees
Santa Clara (headquarters)	California	7,500
Hillsboro	Oregon	15,000
Chandler	Arizona	10,000
Folsom	California	7,300
Rio Rancho	New Mexico	5,500
Hudson	Massachusetts	2,700
Dupont	Washington	1,500
Colorado Springs	Colorado	1,000
Parsippany	New Jersey	900
Riverton	Utah	625
Austin	Texas	550
San Diego	California	400
Shrewsbury	Massachusetts	400
Thousand Oaks	California	300
Los Angeles	California	250
Columbia	South Carolina	150
San Luis Obispo	California	145
Chantilly	Virginia	140
Irvine	California	130
San Jose	California	100
Raleigh	North Carolina	70

SOURCE: http://www.intel.com/jobs/usa/sites/index.htm.

employees in its Santa Clara headquarters, Intel's campus in Hillsboro, Oregon, is twice as large. With 15,000 employees in its Hillsboro branch, Intel is the largest private employer in Oregon. Its second-largest location is in Chandler, Arizona, which offers 10,000 jobs. Intel's campus in Rio Rancho, New Mexico, has 5,500 employees, which makes it the largest private industrial employer in the Albuquerque metropolitan area.

A complete NETS dataset would allow us to measure more precisely how many establishments Silicon Valley firms manage outside California. Unfortunately, a dataset for the whole nation is not ready yet. What we can do is to choose some large firms in Silicon Valley, calculate their employment in the Bay Area, and compare those numbers with total

employment available for the Duns Business Rankings. According to our calculation, the top 40 firms (by sales) in Silicon Valley together have 32 percent of their total employment in the Bay Area. This ranges from Novellus Systems' nearly 100 percent to 3Com's mere 4 percent.

As a successful start-up becomes a mature company, it will develop new needs that require different cost-benefit considerations, or it may be that the company simply cannot conduct its business successfully unless it branches out to other locations. Although its headquarters is likely to remain in Silicon Valley, it will look elsewhere to accommodate its growth. A famous example is the hard disk drive industry that was born in Silicon Valley but later had to move manufacturing operations to Southeast Asia to maintain its competitiveness (McKendrick, Doner, and Haggard, 2000). A serious question for the state of California is how, if possible, to keep spillovers from Silicon Valley within California. This is a particularly relevant question for the fast-growing biotech industry in Silicon Valley and the San Francisco Bay Area as a whole.

Conclusion

Silicon Valley firms do move. In general, more establishments leave the area than move into the area. High-tech establishments are more likely than nontech establishments to move, both into and out of the valley. Establishments moving to Silicon Valley tend to be younger than those moving out. All these findings are consistent with our intuition. Although more establishments relocating out implies that Silicon Valley is losing businesses and job opportunities, it is not a serious problem. On the one hand, establishments moving out tend to go to adjacent cities within the state; on the other hand, new firms created each year overwhelmingly outnumber those moving away, which is more than enough to compensate for the net loss resulting from firm relocation. Thus, instead of worrying about what we might do to keep the businesses, we should focus our attention on how to create new businesses and facilitate their growth.

Although most firms founded in Silicon Valley will remain in the region, the most successful ones among them will almost surely set up

branches elsewhere for operations such as manufacturing that do not benefit much from the Silicon Valley environment. This creates the possibility for the rest of California to accommodate the branching-out of Silicon Valley's successful firms.

5. Conclusion

Silicon Valley's high-tech sector consists of the most dynamic industries in the economy. These industries have unique features and call for careful analysis. The high-tech economy is driven by innovation, and radical changes usually originate from innovative entrepreneurs starting new firms. For these reasons, we have studied high-tech start-ups and industry dynamics in Silicon Valley with the intention of discovering how Silicon Valley changed in the past and the lessons we should learn for the future.

Major Findings

New firms are important for Silicon Valley. As with other high-tech centers, Silicon Valley hosts a wide variety of firms. A multitude of small firms coexist with medium and large firms. Each year, many new firms are founded, which collectively are a major driver of the economic dynamics in Silicon Valley. In fact, firms founded after 1990 created almost all of the job growth during 1990–2001. Young start-ups in Silicon Valley consistently attract a large amount of venture capital, which indicates that these firms are very innovative and growth-oriented. Successful start-ups have remade and will continue to remake Silicon Valley.

Start-ups in Silicon Valley have quick access to venture capital. On average, it takes 11.6 months for Silicon Valley's start-ups to complete their first round of venture finance—five months faster than the national average. The quicker access to capital is found in every major industry in Silicon Valley. This gives start-ups in the region a head start, an important advantage in high-tech industries that advance at a very rapid pace. This large first-mover's advantage implies that start-ups in Silicon Valley will have a better chance to survive, all else equal.

Established firms in Silicon Valley spin off more start-ups. Compared to their counterparts in the Boston area, big companies in

Silicon Valley have more previous employees who start their own venture-backed businesses. Since engineers in successful firms are in the best position to grasp and commercialize cutting-edge innovations, a high rate of spin-offs helps open new markets and creates new jobs. Previous research discusses Silicon Valley's high incidence of firm-level spin-offs based on anecdotal evidence and has identified cultural and legal factors to account for it. Although it remains unclear which theory is closer to the truth, for the first time we have confirmed with empirical data that there are indeed more firm-level spin-offs in Silicon Valley than in other high-tech centers.

Firm relocation is not a serious problem. High-tech start-ups value the hotbed of innovation because that is where new ideas emerge and entrepreneurs cluster. Silicon Valley is a perfect environment for start-ups whose major objective is to develop innovative ideas. On the other hand, when firms become mature and enter the phase of mass production or routine services, their major concern becomes sustainability and they naturally care about operating costs. For those firms or, rather, for certain operations of those firms, Silicon Valley is unattractive. We have investigated whether firms leave Silicon Valley when they have evolved out of the start-up stage. We find that indeed more establishments move out of Silicon Valley than move in, and establishments moving out tend to be older. Establishments tend to stay close to Silicon Valley when they move out. In terms of those moving across state borders, Silicon Valley does see a net job loss, because more jobs are relocated to other states than are relocated to Silicon Valley from outside California. However, the data suggest that firm relocation involves a relatively small proportion of the labor force. Firm birth and death cause much more turbulence than firm relocation. In other words, once firms are established in Silicon Valley, they are very likely to remain there, and intensive entrepreneurial activities certainly compensate for the jobs lost through firm relocation.

Successful firms in the valley are branching out. Although relocation does not occur at significant levels, established firms in Silicon Valley frequently set up branches elsewhere. For many large high-tech companies headquartered in Silicon Valley, their employment within Silicon Valley itself is only a small proportion of their total employment.

Since Silicon Valley is already tightly packed with thousands of firms, fast-growing start-ups are more likely to expand outside the immediate area. As firms expand, they could benefit the rest of California by setting up branches elsewhere in the state.

The high-tech sector experiences rapid structural changes. The high-tech sector consists of a number of diverse industries, which follow different dynamics. On the one hand, the fluctuation of the macro economy has distinctive effects on different high-tech industries; on the other hand, technological innovations in different industries—the drivers of growth in those industries—do not arrive simultaneously. As a result, different high-tech industries may follow unsynchronized business cycles. And thus, at different points in time, the "hot spot" of growth may appear in different industries. For example, the 1990s saw a boom in the computer industry, along with a decline in the defense industry. To catch upturns and avoid downturns in high-tech industries, a high-tech center such as Silicon Valley must accommodate rapid structural changes. This implies that a dynamic labor force is necessary. Previous research has emphasized the "high-velocity labor market" through which workers move frequently from one job to another within Silicon Valley. Such a labor market certainly helps the region's economy adapt to structural changes. In addition, we believe, a set of infrastructure and institutions that enable the labor force to move quickly into and out of Silicon Valley is also crucial for structural changes in the high-tech sector. For example, employment in the software industry in Silicon Valley increased from 48,500 to 114,600 between 1990 and 2001, a phenomenal 136 percent rate of growth. It is impossible to train such a large number of technical workers within such a short period of time. This kind of rapid growth in a certain industry is achievable only through massive migration of the needed labor force.

Policy Implications

State and local governments played only a minor role in the early years of Silicon Valley. The history of Silicon Valley evolved from a tradition of innovative thinking in the region and industry-university networks such as that between the business world and Stanford University. Government's largest effect on Silicon Valley's high-tech

sector was probably the purchase of defense products by the federal government during the Cold War era. State and local governments were not actively involved in the region.

Yet outside Silicon Valley, the recent trend shows that state and local governments can lend an effective helping hand to a regional high-tech economy. From Seattle and Portland to Austin and Denver, state and local governments all have supportive policies for the local high-tech sector. Governments play even bigger roles in the Silicon Valley clones in the rest of the world, such as Cambridge, England; Helsinki, Finland; Tel Aviv, Israel; Bangalore, India; and Hsinchu, Taiwan (Rosenberg, 2002).

To maintain Silicon Valley's success is by no means an easier task than building a Silicon Valley clone. Silicon Valley today faces more competition than ever from high-tech regional economies both domestically and internationally. Supportive policies have been implemented in metro areas all over the country that aim at grabbing a bigger piece of the high-tech economy. In addition, Silicon Valley's success today could become its burden tomorrow when innovations again call for changes. How to keep Silicon Valley growing is a big challenge for California's policymakers. This is especially true today, with the valley struggling through a deep recession.

Policies directly related to Silicon Valley include the federal government's spending on R&D and military goods and its immigration policies, state government's R&D spending and education policy, and local governments' land use policies, and so on. In addition, in any other areas where the private sector has no incentive or capability to solve the problems, government must step in. Examples include building infrastructure, training labor, and preventing further energy crises.

Several policy implications have emerged from our examination of high-tech start-ups and industry dynamics in Silicon Valley.

Promote technological innovation. More than any other sector, the high-tech economy is about innovation and entrepreneurship. Waves of innovation cause business cycles. Silicon Valley has experienced highs and lows many times, and right now the region is struggling in a deep trough. Previous experience proves that Silicon Valley always gets out of a recession on two legs: One is strong demand for high-tech products

from the whole economy, and the other is new demand created by innovations that add a new dimension to Silicon Valley's economy. Although state and local governments can do little to improve the macroeconomic environment of the national economy, they could help promote innovation. University research has always been a major source of innovation, and state government should continue its strong support to research universities. Big budget cuts for the University of California system will severely affect the prospect of the high-tech sector off campus. Moreover, the California delegation in Washington, D.C., should place a high priority on securing R&D dollars for California from the federal government. As the state economy becomes more and more reliant on high-tech industries, support for R&D and innovation not only helps Silicon Valley and the rest of the Bay Area, but it also greatly benefits the Los Angeles and San Diego areas, which are continuing to expand their own high-tech sectors.

Encourage firm founding. Our findings show that although some firms do move out of Silicon Valley, it is not a serious problem. On the one hand, they are likely to move to nearby cities and stay within the state; and on the other hand, firm formation and growth create new jobs that overwhelmingly outnumber jobs lost through firm relocation. Job creation in Silicon Valley is primarily achieved by new firms. Thus, instead of worrying about losing businesses because of the high cost of living and doing business in Silicon Valley, state and local governments should encourage firm founding. Offering favorable tax breaks, opening industrial parks, building high-tech incubators, and providing seed capital for commercialization of research are widely used policy levers. Previous research has shown that a primary factor determining a high-tech start-up's location is where its founder would like to live (Cooper and Folta, 2000). Thus, continuously improving the quality of life in Silicon Valley and the Bay Area as a whole is crucial for the vitality of the high-tech economy in this area.

Look beyond Silicon Valley. The high-tech sector is not a disconnected economy, nor is Silicon Valley an isolated region. Silicon Valley is well embedded in the San Francisco Bay Area and well connected to the rest of the state economy. Most of the firms relocating out of Silicon Valley migrate to nearby cities in the Bay Area. The rest of

the Bay Area has undoubtedly benefited from the proximity of Silicon Valley and has quite a strong high-tech economy. Our data show that entrepreneurial activities in the 1990s were intensive in the whole Bay Area, both inside and outside Silicon Valley. Venture capital investment is also abundant for the rest of the Bay Area. State policies regarding Silicon Valley should take into account Silicon Valley's connection with the rest of the state economy. For example, many people who work in Silicon Valley live a considerable distance from it, seeking more affordable homes. Thus, housing development and transportation policies in many other Bay Area cities help to solve Silicon Valley's housing problems. We have also found that large firms in Silicon Valley often hire only a small proportion of their total employees from Silicon Valley or even the Bay Area. This suggests that other regions in the state have the opportunity to benefit from spillover from Silicon Valley by hosting branches of its firms. State government should try to understand not only new firm formation but also the concerns of mature firms in Silicon Valley. In particular, state government could provide incentives for large firms to set up their manufacturing or distribution arms within the state. State government could also improve transportation networks between the Bay Area and the Central Valley that facilitate Silicon Valley's branching out to the latter area. In addition, local governments in the rest of the Bay Area and in the Central Valley should be more proactive in accommodating businesses branching out from Silicon Valley.

Maintain a dynamic labor pool. Two conflicting factors characterize the high-tech labor force. On the one hand, the high-tech sector primarily hires technical workers whose skills are highly specialized and take time to acquire; on the other hand, the high-tech sector is dynamic, with its core technologies evolving quickly. This implies that the skills acquired in school three years ago may be obsolete today. Moreover, certain high-tech industries often experience explosive growth, such as the software industry in the 1990s, which creates a high demand for certain types of technical workers within a short period. Whether Silicon Valley can evolve rapidly hinges upon whether its labor force can quickly upgrade its skills or meet completely new demands. State government should continue to support universities and colleges as

vehicles for continuously retooling the labor force. Employers in Silicon Valley should recruit new talent not only through local colleges and universities but also by recruiting and hiring highly qualified immigrants. Immigrants have played an important role in Silicon Valley's growth. They are a major source of Silicon Valley's entrepreneurs and innovation. Immigrants also provide a large reserve of high-quality engineers and scientists capable of satisfying sudden surges of demand for certain talents in some industries. State government in cooperation with federal authorities should keep the door open to international talent, both at local universities and in the high-tech industries. This has emerged as a particularly crucial issue because immigration policies have now entered the equation of homeland security.

Appendix A

Geographic and Industrial Definitions

Geographic Definition of Silicon Valley

Our definition of Silicon Valley includes all of Santa Clara County and adjacent cities in Alameda, San Mateo, and Santa Cruz Counties.

City	Zip Code
Santa Clara County	
All	All
Alameda County	
Fremont	94536–39, 94555
Newark	94560
Union City	94587
San Mateo County	
Atherton	94027
Belmont	94002
East Palo Alto	94303
Foster City	94404
Menlo Park	94025
Redwood City	94061–65
San Carlos	94070
San Mateo	94400–03
Santa Cruz County	
Scotts Valley	95066–67

Definition of Industry Groups in the NETS Data Used in This Study

Industries are listed by their SIC code; "n.e.c." means not elsewhere classified.

Industry Group	SIC Code
Agriculture, forestry, and fishing	01–09
Mining	10–14
Construction	15–17
Manufacturing	20–39
Transportation, communication, electric, gas, and sanitary services	40–49
Wholesale trade	50–51
Retail trade	52–59
Finance, insurance, and real estate	60–67
Services	70–89
Government	91–97

Definition of High-Tech Industries in the NETS Data

Industry	SIC Code
Bioscience	
Drugs	283
Laboratory apparatus and analytical, optical, measuring, and controlling instruments	3821, 3823–24, 3827, 3829
Surgical medical and dental instruments and supplies	384
Medical laboratories	8071
Computers/communications	
Electronic computers	3571
Computer storage devices	3572
Computer terminals	3575
Computer peripheral equipment, n.e.c.	3577
Telephone and telegraph apparatus	3661
Radio and television broadcasting and communications equipment	3663
Communications equipment, n.e.c.	3669
Printed circuit boards	3672

Electronic components, n.e.c.	3679
Magnetic and optical recording media	3695
Defense/aerospace	
Small arms, ammunition	348
Electron tubes	3671
Aircraft and parts	372
Guided missiles and space vehicles	376
Tanks and tank components	3795
Search, detection, navigation, guidance, aeronautical, and nautical systems instruments and equipment	381
Environmental	
Industrial and commercial fans and blowers and air purification equipment	3564
Service industry machinery, n.e.c.	3589
Sanitary services	495
Scrap and waste materials	5093
Semiconductors	
Special industry machinery	3559
Semiconductors and related devices	3674
Instruments for measuring and testing electricity and electrical signals	3825
Software	
Computer programming services	7371
Prepackaged software	7372
Computer integrated systems design	7373
Computer processing and data preparation and processing services	7374
Information retrieval services	7375
Innovation services	
Wholesale of computers and computer peripheral equipment and software	5045
Wholesale of electronics parts and equipment, n.e.c.	5065
Computer facilities management services	7376
Computer rental and leasing	7377

Computer maintenance and repair	7378
Computer-related services, n.e.c.	7379
Engineering services	8711
Research and testing services	873
Professional services	
Commercial printing	275
Manifold business forms	276
Service industries for the printing trade	279
Investors, n.e.c.	6799
Advertising	731
Consumer credit reporting agencies	732
Mailing, reproduction, commercial art and photography, and stenographic services	733
Personal supply services	736
Legal services	81
Architectural services	8712
Surveying services	8713
Accounting, auditing, and bookkeeping services	872
Management and public relations services	874

Appendix B

The Data

Here we give a detailed discussion of the two longitudinal databases we used.

The NETS Data

The NETS database was constructed by Walls & Associates, who derived the raw data from Dun & Bradstreet (D&B). D&B, which has been collecting business data for more than 160 years, offers business-to-business credit information on companies throughout the world. The D&B data include information on the location, industry category, ownership, and employment of almost all businesses in the United States.

Although the goal of D&B is not to collect and organize data for scholarly research, it does have an incentive to ensure the accuracy of its data. Serious inaccuracies could hurt D&B's business and might even result in lawsuits. D&B has thus established a complicated quality control system, which has resulted in a relatively accurate and reliable database. However, D&B data are by no means without limitations. The main source of bias comes from its criterion of inclusion. Only firms that seek credit ratings or whose credit ratings are demanded by business partners have an incentive to report their activities to D&B. D&B has no information about businesses that do not report to them. Early evidence suggests that D&B data tend to overrepresent the manufacturing sector and new firms may not be completely covered or not included in their early years of existence. Nonetheless, with all their shortcomings, D&B data are one of the most widely consulted sources of information for academic research, mainly because firm-level data are always hard to acquire and D&B data are conveniently available, cover nearly the whole economy, and are of reasonably good quality. Many previous studies on industry dynamics such as Birch (1987) and Audretsch (1995) have used refined D&B data.

Walls & Associates teamed up with D&B to convert their archival establishment data into a time series: the NETS database. Walls & Associates first used D&B's Duns Marketing Information file, which followed more than 22 million establishments from 1990 to 2001, to determine which establishments were active in January of each year. Then they retrieved information about each establishment from other D&B files (e.g., the credit rating file) to create a time series with rich firm-level information.

In the NETS database, the basic unit of observation is the "establishment." An establishment is a business or industrial unit at a single physical location that produces or distributes goods or provides services. For example, a single store or factory is an establishment. Many companies own or control more than one establishment, and those establishments may be located in different geographic areas and may be engaged in different kinds of business. D&B assigns a unique nine-digit DUNS (Data Universal Numbering System) number to each establishment. D&B also links the DUNS numbers of parent companies, headquarters, subsidiaries, and branches to form corporate family structures. The NETS database has all such information included, so that we are able to tell whether a new establishment is a start-up company or a newly established branch of an existing company.

Specifically for the purpose of our study, Walls & Associates cut a PPIC extract from their NETS database. This dataset covers all the establishments that were ever located in 15 counties during 1990–2001. The 15 target counties include: ten counties in the San Francisco Bay Area (Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Santa Cruz, Solano, and Sonoma),[1] two counties in the Boston area (Middlesex and Suffolk), and three counties in the Washington, D.C., area (Arlington, Virginia; Fairfax, Virginia; and Montgomery, Maryland). The data for the ten counties around San Francisco Bay completely cover Silicon Valley as we defined it and, in addition, allow us to look at a bigger picture beyond the valley. The data

[1]For most of our analysis, we do not use all the data from the ten counties in the Bay Area. As defined in Appendix A, Silicon Valley covers only Santa Clara County and some adjacent cities in Alameda, San Mateo, and Santa Cruz Counties.

for the other two high-tech centers, Boston and Washington, D.C., enable us to make comparisons.

One of our tasks is to measure start-up growth over time. Firm growth is usually measured by employment or sales. D&B does collect data on firm sales. However, for various reasons, a very small proportion of firms choose to report their sales numbers. Firms are more likely to report their employment. For example, our dataset has self-reported employment for 84 percent of Silicon Valley's high-tech firms active in 2001. Small firms are more likely to have missing data. For example, if we exclude the Silicon Valley high-tech firms that never hired more than five people, 97 percent of the employment data will be self-reported. Fortunately, an establishment's employment data are usually not missing for all years. If a data point is missing for a year between two self-reported data points, then D&B or Walls & Associates will fill it in according to simple smoothing formulae. If there is a missing data point before or after a series of self-reported data points, it is filled in by extrapolation. In rare cases where the employment data are completely missing, D&B or Walls & Associates will enter their estimates based on industry average.

To test the reliability of the NETS data, we compared business size distribution in NETS with that available at the Economic Development Department (EDD) of California. The EDD dataset also counts an establishment as a business unit, which makes it comparable with NETS. It defines the employment at an establishment as "insured wage earners on the payroll." Any employer hiring one or more persons, who pays wages in excess of $100 during a calendar quarter, and who is not engaged in an exempt activity, is subject to the Unemployment Insurance provision of the California Unemployment Insurance code. Table B.1 presents business size distribution in four counties that cover Silicon Valley: Alameda, San Mateo, Santa Clara, and Santa Cruz. Although the NETS data cover self-employed people, we have excluded them from our calculation because the EDD data do not include them. The EDD dataset is a snapshot as of September 2001. We use the NETS data collected in January 2001.

As Table B.1 shows, in Alameda and Santa Clara Counties, the NETS covers more establishments than the EDD data in every size

Table B.1

Business Size Distribution in NETS and EDD Data, 2001

	0–4	5–9	10–19	20–49	50–99	100–249	250–499	500–999	1,000+
Alameda									
EDD	28,105	6,229	4,598	3,579	1,511	788	198	79	43
NETS	38,201	8,507	5,298	4,003	1,614	874	212	88	59
San Mateo									
EDD	14,061	3,412	2,413	1,918	743	399	110	44	22
NETS	21,277	4,559	2,784	2,035	775	425	111	31	37
Santa Clara									
EDD	27,949	7,794	5,569	4,612	1,934	1,119	278	120	76
NETS	48,614	10,053	6,344	4,968	1,969	1,189	304	161	119
Santa Cruz									
EDD	4,561	1,347	909	714	238	121	25	10	3
NETS	9,487	1,879	975	596	227	104	16	8	8

NOTE: The EDD data are available at http://www.calmis.cahwnet.gov/file/indsize/1sfcoru.htm.

category. In San Mateo County, the NETS is bigger than the EDD sample except in one category. In Santa Cruz County, the EDD picks up more firms than NETS in size categories bigger than 20, except for 1,000+. In every county, the NETS sample covers many more small firms that employ fewer than 20 people. The difference in the 0–4 category is most significant. For example, in Santa Cruz County, the NETS data include more than twice as many size 0–4 firms as the EDD data. A comparison of business size distribution for some other years yields similar results: The NETS data always capture far more small firms than the EDD data; although the difference becomes smaller for larger firms, the NETS is still likely to have more of them. A more complete coverage of the small firms is particularly valuable for studying start-ups.

Table B.2 compares county-level employment series from the EDD data and those from the NETS. The NETS data consistently produce a larger employment figure. This is true in every year for every county. In some cases, the difference is very large. For example, in 1993 in Santa Clara County, the NETS data documented 30 percent more employees than the EDD data. To some extent, a larger employment number

Table B.2

Employment Series in NETS and EDD Data, 1990–2001

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Alameda												
EDD	—	—	—	591,300	590,600	607,000	620,800	639,100	660,500	683,600	71,100	719,600
NETS	709,496	679,448	677,404	750,168	730,025	738,186	733,484	742,097	796,386	793,967	802,609	838,795
San Mateo												
EDD	295,600	298,100	291,500	294,200	296,300	305,800	319,100	333,300	345,100	357,900	375,800	375,400
NETS	364,531	351,646	344,535	365,465	365,310	355,550	361,851	370,309	380,917	371,438	383,188	408,199
Santa Clara												
EDD	819,500	810,900	797,200	802,000	805,000	836,400	885,000	931,700	961,500	976,600	1,035,000	1,021,000
NETS	1,055,389	1,017,015	988,208	1,054,477	1,028,791	1,032,777	1,048,374	1,070,466	1,079,035	1,077,960	1,131,221	1,174,771
Santa Cruz												
EDD	94,900	96,100	94,800	95,400	96,600	97,700	99,200	101,600	103,000	103,200	105,600	107,200
NETS	105,471	101,451	101,219	110,638	113,370	109,298	109,186	112,064	114,591	116,455	117,184	115,478

NOTE: The EDD data are available at http://www.calmis.cahwnet.gov/file/indsize/1sfcoru.htm.

simply reflects the fact that the NETS data cover more firms, which could be a good feature of our data. However, this good feature is not cost-free. The NETS data contain a large number of very small firms. The data for those small firms tend to be noisy, which adds more noise to the NETS data.

As we have mentioned, a firm chooses to be included in the D&B raw data when it needs a DUNS number. In certain circumstances, that need may suddenly become pertinent for many firms, and hence many existing firms that are not in the D&B database will jump in simultaneously. This kind of behavior is more common for small firms, which creates more noise in the NETS data. For example, we see a big surge in employment from 1992 to 1993 in the NETS data but not in the EDD data. In the 1992–1993 period, the California economy came out of a severe recession, and therefore an increase in employment was expected. But the 6–10 percent increase in the NETS data is too dramatic to be credible.

We have attempted to discover possible reasons to explain the surge in 1993. As part of President Clinton's mandate to streamline the procurement process through the use of electronic commerce, the federal government adopted the D&B DUNS number as a principal contractor identification code in 1993. This means that suppliers doing business with government agencies via Electronic Data Interchange would be required to submit their DUNS number as part of the registration and transaction processes. This might have pushed many existing firms into the D&B database. We see a nationwide surge in the number of business units in the 1993 edition of D&B's business census. This is also reflected in our NETS data. The problem could be partly solved if every establishment reported its starting date as required, but a large proportion of small firms failed to do so. For this reason, we should use caution when interpreting economic trends in the NETS data.

We have compared some of the NETS data and the EDD data at the county level. Our general conclusion is that the NETS data provide a more complete coverage of business enterprises and particularly of small firms. The drawback that comes with the more complete coverage is that it is subject to noise created by small firms. The above comparison reveals only some of the properties of the NETS data at the aggregate

level. At the firm level, the NETS data offer a very rich pool of information such as firm location, ownership, industry, employment, and the changes in such variables over time. This wealth of information is unparalleled by any other database.

The VentureOne Data

The second dataset is provided by VentureOne, a leading venture capital research company. VentureOne claims that it has "the most comprehensive database on venture-backed companies." Our data cover venture capital deals completed from the first quarter of 1992 through the fourth quarter of 2001. They include 29,277 rounds of financing involving 11,029 firms. Among those firms, 83.53 percent were founded in or after 1990. The VentureOne data provide detailed information about all the venture-backed start-ups. Interesting firm-level variables include the start year, address, industry, employment, current business status, current ownership status, closing date of each round of financing, the amount of capital raised in each round, and so on.

VentureOne categorizes venture-backed firms into 16 different "industry segments." Table B.3 shows the amount of venture capital invested and the number of deals completed in each industry. An overwhelming majority of venture-backed start-ups should be classified as high-tech. Even in the retailing industry, most venture-backed firms qualify as high-tech because they are Internet-related. Only a tiny proportion of firms in our dataset do not fall into our definition of high-tech, such as restaurants in the retailing industry. Since VentureOne does not use the SIC codes, we have no consistent way to exclude nontech firms from our analysis other than relying on subjective judgment. Thus, we decided to use the entire dataset.

VentureOne also provided a separate dataset containing information about start-up founders. An "EntityID" variable allows us to match the firm data with the founder data. The biographical information of founders is available, including the previous working experiences of the founder. This enables us to do some elementary studies of entrepreneurs, such as what kind of people tend to found venture-backed start-ups.

To do a preliminary reliability test of the VentureOne data, we compared them with the only alternative comprehensive venture capital

Table B.3

Real Venture Capital Investment in the United States, by Industry, 1992–2001

Industry	Venture Capital Raised ($ billions)[a]	% of Total Venture Capital	No. of Deals
Communications	72.926	23.72	3,893
Software	57.058	18.56	7,142
Consumer/business services	52.830	17.18	5,025
Information services	26.436	8.60	2,522
Biopharmaceutical	21.845	7.11	2,140
Retailing	14.617	4.75	1,062
Medical devices	13.579	4.42	1,885
Semiconductor	11.627	3.78	1,154
Electronics	11.343	3.69	1,476
Healthcare	7.902	2.57	932
Medical information services	7.347	2.39	915
Consumer/business products	5.554	1.81	579
Advance/special material and chemical	1.395	0.45	200
Other	1.337	0.43	199
Energy	1.116	0.36	76
Agriculture	0.516	0.17	77
Total	307.426	100	29,277

[a]In 1996 dollars.

database, the PricewaterhouseCoopers/Venture Economics/National Venture Capital Association MoneyTree Survey. The data from the MoneyTree Survey do have one advantage in that they cover a longer time period. However, our main purpose is to study industry dynamics through firm formation, growth, and mortality but not the trend of venture capital investment. So we need detailed information about venture-backed firms. By this criterion, the VentureOne data are more suitable for us.

Table B.4 compares some aggregate statistics from the MoneyTree Survey and the VentureOne data. The VentureOne data show a higher sum of venture capital investment for every year except 2001. We acquired our data from VentureOne in late December 2001, when the fourth-quarter data were not completed yet. That may explain the deficit of the VentureOne data in 2001. In terms of companies covered, the

Table B.4

Venture Capital Investment by MoneyTree Survey and VentureOne Data

	MoneyTree Survey[a]			VentureOne		
Year	Sum Invested ($ millions)	No. of Companies	Average per Company	Sum Invested ($ millions)	No. of Companies	Average per Company
1992	3,827.56	1,054	3.63	9,230.75	1,126	8.20
1993	4,565.53	945	4.83	10,220.66	1,162	8.80
1994	3,792.89	954	3.98	8,043.74	1,230	6.54
1995	5,693.46	1,265	4.50	13,389.43	1,536	8.72
1996	11,386.77	1,809	6.29	21,313.05	2,105	10.12
1997	14,823.33	2,385	6.22	20,474.79	2,329	8.79
1998	19,843.17	2,821	7.03	24,752.63	2,568	9.64
1999	54,499.93	4,202	12.97	67,480.78	4,027	16.76
2000	102,308.33	5,608	18.24	112,214.10	5,483	20.47
2001	37,672.50	3,224	11.69	32,524.21	2,933	11.09

[a]Information is current as of February 20, 2002, and is available at http://www.nvca.org/.

VentureOne data report more venture-backed companies from 1992 to 1996. Since then, the MoneyTree Survey has covered more companies. The discrepancies are quite small, although we have to recognize that a larger set of companies in one dataset does not necessarily encompass the smaller number of companies in the other dataset.

The most significant disagreement between the two datasets is the average amount of money raised by each company. Except for 2001, the VentureOne data always produce a higher average. And the trend is the earlier the data, the bigger the difference. In 1992, the average venture capital per company in the VentureOne data is more than twice as much as in the MoneyTree Survey. Many possible reasons can explain the differences. For example, the definition of venture capital may not be identical. We notice that VentureOne actively tracks only venture capital firms that manage more than $20 million. This may bias the VentureOne data toward larger venture capital deals. Because most deals became very large in the late 1990s, this bias could have become smaller. Overall, it seems that there is not enough evidence to conclude that one dataset is better than the other.

Appendix C

A Snapshot of the Silicon Valley Economy

Using an extract from the NETS database, we assemble a collection of statistics here to describe the Silicon Valley economy in 2001.

Table C.1

Total Number of Establishments and Employees in Silicon Valley, 2001

	High-Tech	Nontech	Total
Total establishments	25,787	77,334	103,121
Total employees	672,825	903,332	1,576,157

Table C.2

High-Tech Establishment Category in Silicon Valley, 2001

Establishment Category	Headquarters	Branches	Stand-Alone	Total
Alive in 2001	1,682	2,621	21,484	25,787
% of total	6.52	10.16	83.31	100

Table C.3

Establishment Size Distribution in Silicon Valley, 2001

No. of Employees	High-Tech	Nontech
0–4	15,993	51,924
5–9	3,405	10,800
10–19	2,372	6,556
20–50	2,227	5,402
51–100	823	1,598
101–250	579	739
251–500	207	184
501–1,000	93	83
1,001–2,500	63	34
2,500+	25	14
Total	25,787	77,334

Table C.4

Establishment Age Distribution in Silicon Valley, 2001

Establishment Year[a]	High-Tech	Nontech	Total
1989 or before	7,570	30,777	38,347
1990	653	1,681	2,334
1991	743	1,756	2,499
1992	1,437	5,318	6,755
1993	1,034	2,283	3,317
1994	1,222	2,941	4,163
1995	1,441	3,475	4,916
1996	1,821	5,202	7,023
1997	1,877	3,729	5,606
1998	2,317	5,019	7,336
1999	2,099	4,913	7,012
2000	3,573	10,240	13,813
Total	25,787	77,334	103,121

[a]This refers to the variable "FirstYear," which is a firm's start year or, in case the start year is missing, the year when its data first entered the D&B database.

Table C.5

Total Establishments in Silicon Valley, by Industry Group, 2001

Industry Group	No. of Establishments	No. of Employees
Agriculture, forestry, and fishing	1,758	12,496
Mining	35	315
Construction	6,886	55,795
Manufacturing	8,163	459,388
Transportation, communication, and utilities	3,402	71,326
Wholesale trade	6,907	85,153
Retail trade	17,291	181,026
Finance, insurance, and real estate	9,237	85,048
Services	49,039	580,742
Government	403	44,868
Total	103,121	1,576,157

Table C.6

Total High-Tech Establishments in Silicon Valley, by Industry, 2001

Industry	No. of Establishments	No. of Employees
Semiconductors	816	103,443
Computers/communications	1,127	150,974
Bioscience	847	51,854
Defense/aerospace	94	27,567
Environmental	244	8,342
Software	4,505	114,639
Innovation services	6,257	112,150
Professional services	11,897	103,856
Total	25,787	672,825

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