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Authors

Saxenian, AnnaLee
Goldstein, Karl

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AnnaLee Saxenian and
Karl Goldstein

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ABSTRACT

Software production has experienced a dramatic nationwide boom in recent years, expanding faster than any other sector of high-technology industry. Centers of software production have the potential to generate high-paying employment without pollution and expensive infrastructure, factors which have earned the attention of economic development planners. However, the factors which lead to the creation and perpetuation of such centers have been little studied.

In this paper, the researchers have studied the development patterns and prospects of one regional center of software production, located in the northern Alameda County cities of Berkeley, Alameda, Oakland, and Emeryville. The study included three components: (1) quantitative analysis of economic data, to situate software production within the context of the regional economy; (2) census of software firms, to construct a comprehensive overview of the industry; (3) open-ended interviews with people related to the industry, to form a qualitative impression of the industry's workings.

Overall, the regional software industry proved extremely dynamic. Although generally growing and increasing in importance relative to the rest of the economy, it was marked by constant turnover as firms emerged, grew, dissolved, or changed location. This dynamism depends as much on networks among programmers, entrepreneurs, and institutional representatives as it does on economic policies or conditions. Furthermore, the regional software industry possesses a unique character, as distinguished from "Silicon Valley," attributable primarily to the influence of UC Berkeley and related institutions.

I. Introduction

In recent decades, numerous regions around the nation and the world have placed their bets on high-technology production as a strategy for economic growth. For the most part, these dreams have gone unfulfilled. Region after region has failed to become the next Silicon Valley, even when they apparently possessed all the ingredients for success. The allure of making satellites and microchips faded even more in the late 1980s, when most high-technology manufacturing sectors experienced severely curtailed growth and even decline, and established centers such as Route 128 in Massachusetts entered into crisis.

In the midst of this generally gloomy picture, the nation's software industry has experienced a dramatic boom in recent years, bubbling up from its previously marginal position to assume a leading role in high-technology production and employment. The overall growth in software reflects the need to adapt computers and electronic equipment to an infinite number of tasks, as they steadily infiltrate the realms of industry, commerce, education, and the household.

Aside from the software industry's favorable economic outlook in the near future, it also appeals to economic development planners for several reasons. Wages are high and capital investment and other barriers to entry are low, allowing small firms to start up and often thrive. Software production does not require large amounts of space or sizable public investments in industrial infrastructure. It is also an inherently "clean" industry, in contrast to other high-technology manufacturing activities.

Given the apparent potential of the software industry to generate economic development with minimal negative implications, we explored the actual development patterns and prospects of the industry in Northern Alameda County. We sought to answer the following questions:

- What role has the software industry played in the overall regional economy, and what are current trends?
- What is the composition of the regional software industry, in terms of firm size, location, and activities?
- What factors contribute to the formation and continued success of the regional software industry?
- What are the limitations on promotion of the software industry as a strategy for regional development?

Methodology

To answer these questions, we employed three methods:

- Quantitative analysis of published economic data
- Census of all regional software firms located from published sources and personal references
- As a complement to the quantitative data, approximately 35 open-ended interviews with owners and managers of companies, academic researchers, venture capitalists, and economic development officials

## II. The Role of the Software Industry in the Regional Economy

Our analysis of the software industry in the regional economy relied on economic data published in *County Business Patterns*. The lack of specific industry information for each city limited the analysis to the county level, rather than the study region. We found the following key trends:

- Employment in high-technology services, which includes programming, prepackaged software, integrated systems design, data processing, information retrieval, and computer maintenance and repair, has expanded rapidly in Alameda County during the 1980s. Total employment in the sector grew from less than 1,000 to almost 7,000 from 1975 to 1990 (Figure 1). Moreover, programming and prepackaged software, which comprised our definition of the "software industry," accounted for the bulk of this growth.

- The *relative* importance of high-technology services in the overall economy of Alameda County also increased; it went from accounting for less than 0.2 percent to over 1 percent of total employment from 1975 to 1990 (Figure 2). This *five-fold* relative increase was more than for California as a whole (*two-fold*), as well as for Santa Clara County (*three-fold*), the heart of "Silicon Valley."

- Alameda County's statewide share of total employment *within* the high-technology services sector registered a modest increase from 1975 to 1990, from about 2.8 percent to over 5 percent (Figure 3). However, the County's share of statewide employment in the *software* subsector experienced a *six-fold* increase over the same period.

- Confirming this general trend, the software subsector's share of employment *within the high-technology services sector as a whole* expanded rapidly from 1975 to 1990. In the county, the subsector's share zoomed from less than 10 percent to about 70 percent of all employment in high-technology services (Figure 4).

- Location quotient analysis for all subsectors showed that Alameda County still shows significantly lower concentrations of economic activity in high-technology services than in Santa Clara County (Figure 5). Prepackaged software was the only subsector where Alameda County approached Santa Clara County by this measure.

Figure 1. Alameda County total employment, software and computer services, 1975-1990
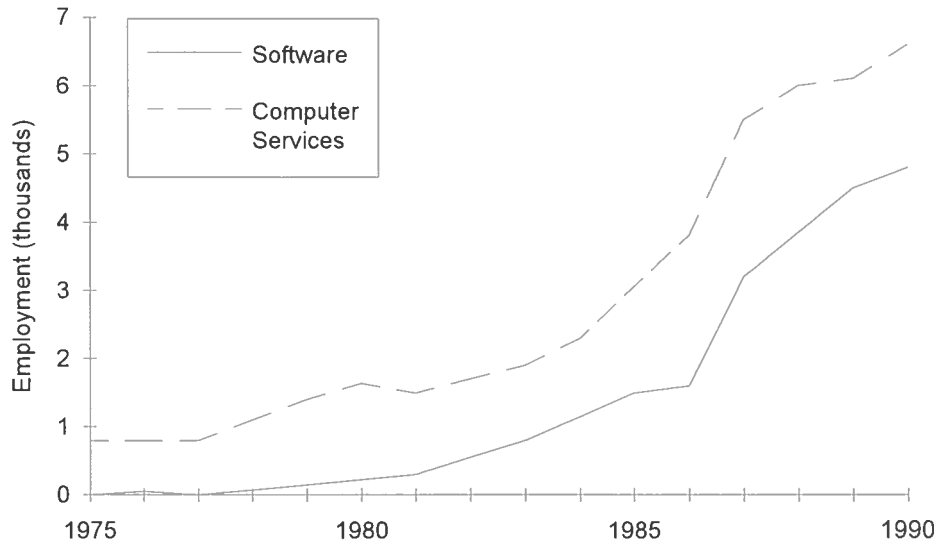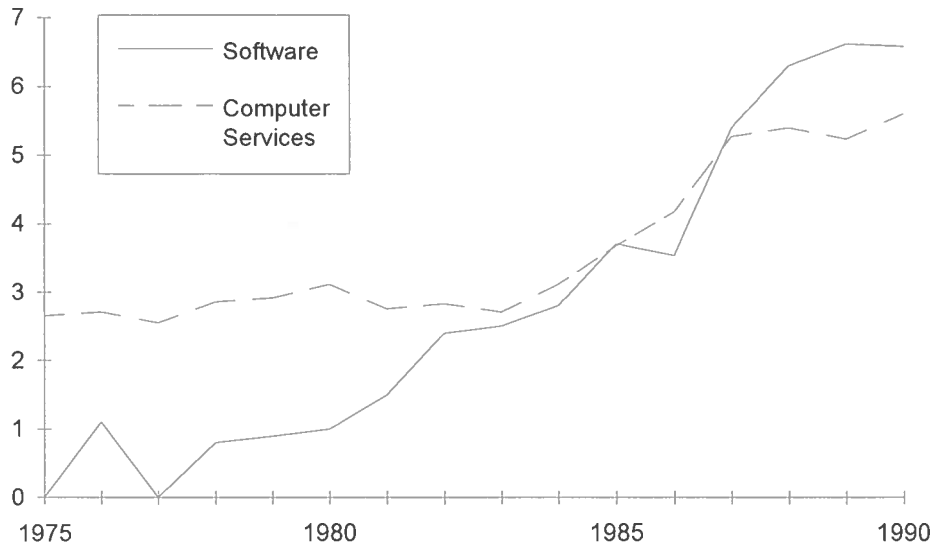

Figure 2. Computer and data processing services as a percentage of total employment, Alameda and Santa Clara Counties and California, 1975-1990
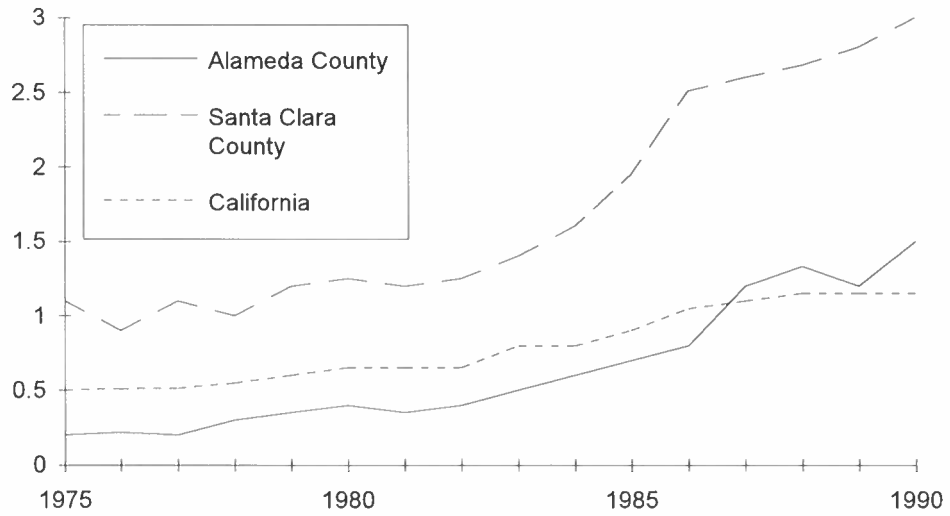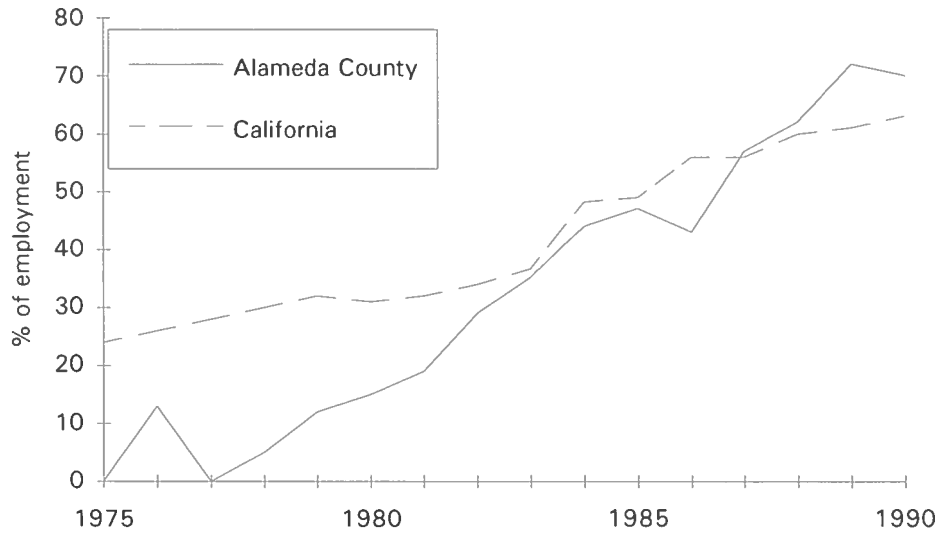

Source: County Business Patterns, 1975 - 1990

Figure 3. Software and computer services employment, Alameda County as a percentage of California, 1975-1990
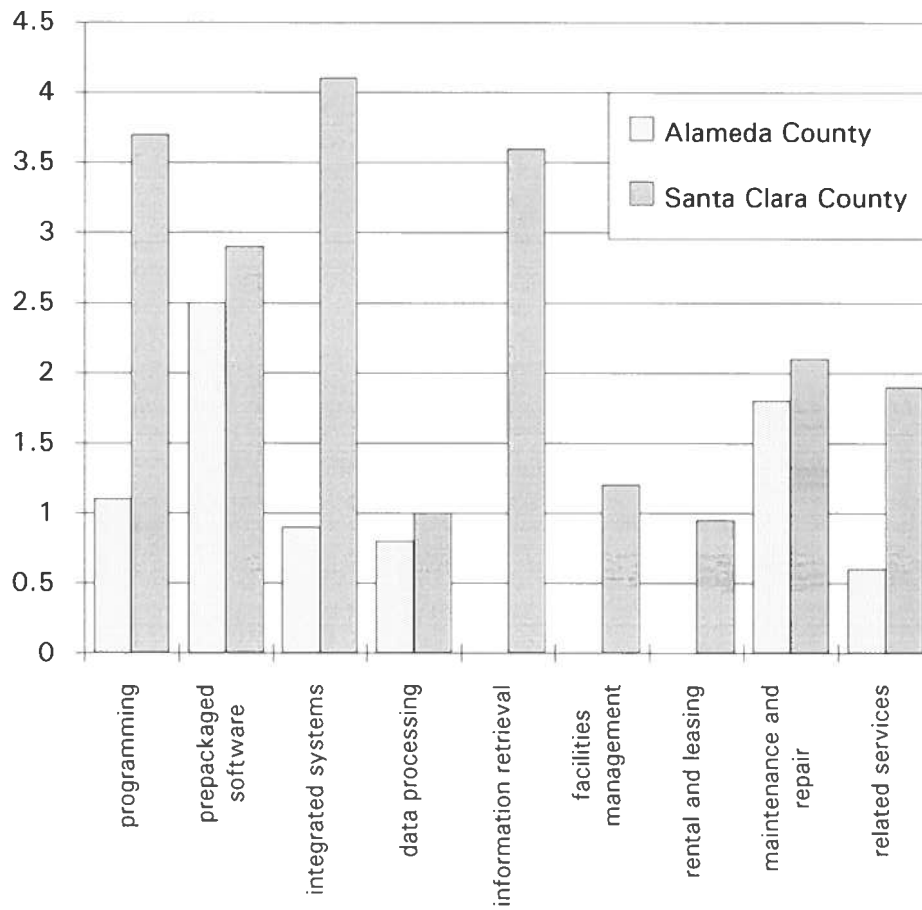

Figure 4. Computer programming and software as a percentage of all computer services, Alameda County and California, 1975-1990

Source: County Business Patterns, 1975 - 1990

Figure 5. Location quotient analysis, computer and data processing services, Alameda and Santa Clara Counties

Legend:
- Alameda County
- Santa Clara County

Categories (x-axis): programming, prepackaged software, integrated systems, data processing, information retrieval, facilities management, rental and leasing, maintenance and repair, related services

III. Composition of the Regional Software Industry

Taking the Census

Our census of local software firms relied initially on several published directories and the Yellow Pages. To complement and verify this information, we called each firm and requested the following information:

- Name
- Current address
- Principal products
- Sales
- Employees
- Previous locations
- Information about other firms to add to our list

Results of the Census

A quantitative summary of the census results is presented in Figures 6-15.

- Predictably, regional firms tend to be small in terms of both revenues and employment. The majority of firms have fewer than 20 employees, and less than $5 million in annual revenues (Figures 6 and 7).
- Oakland possesses the largest number of firms, although they tend to be smaller than in the other cities. Berkeley possesses the second-largest number of firms (Figure 8).
- Existing firms are most likely to have formed in the first half of the 1980s. Since 1986, firm formation seems to have slowed (Figure 9).
- Although they have fewer firms, total employment and revenues in the software industry appear to be higher in Alameda and Emeryville compared to Berkeley and Oakland (Figures 10 and 11). This is also suggested by the larger average number of employees and revenues in the former two cities (Figures 12 and 13).
- The few large firms in the region contribute a disproportionate share of total industry revenues and employment (Figures 14 and 15).
- The products of regional software firms are highly diverse, without any clear regional specialties.
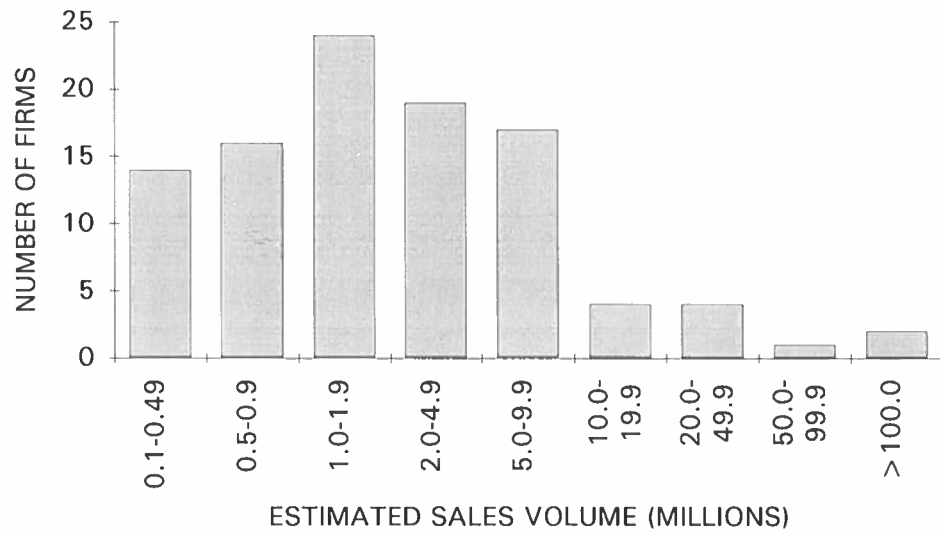
Problems with the Census

In the process of compiling the census, several problems with regard to analysis of the industry became evident:

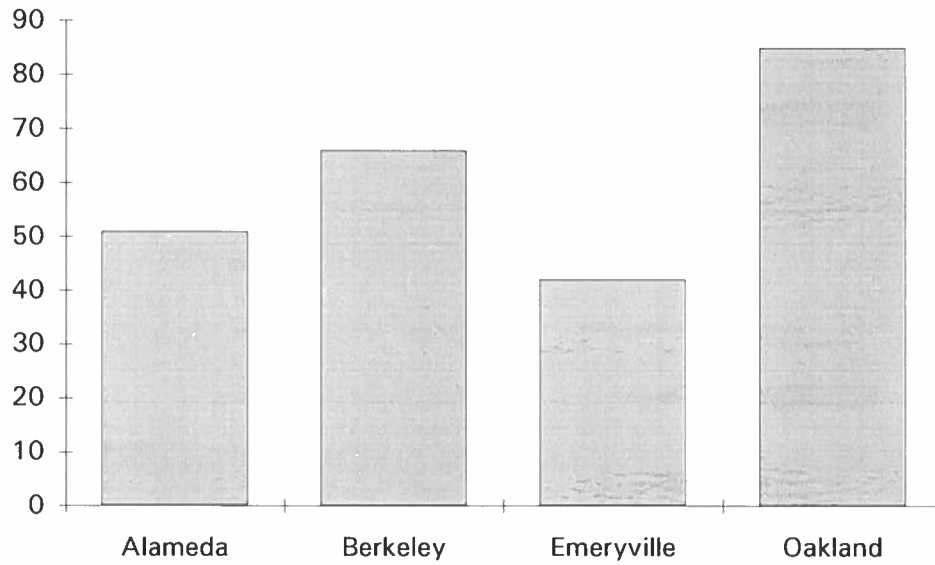FIGURE 6. DISTRIBUTION OF FIRMS BY NUMBER OF EMPLOYEES - ALL CITIES
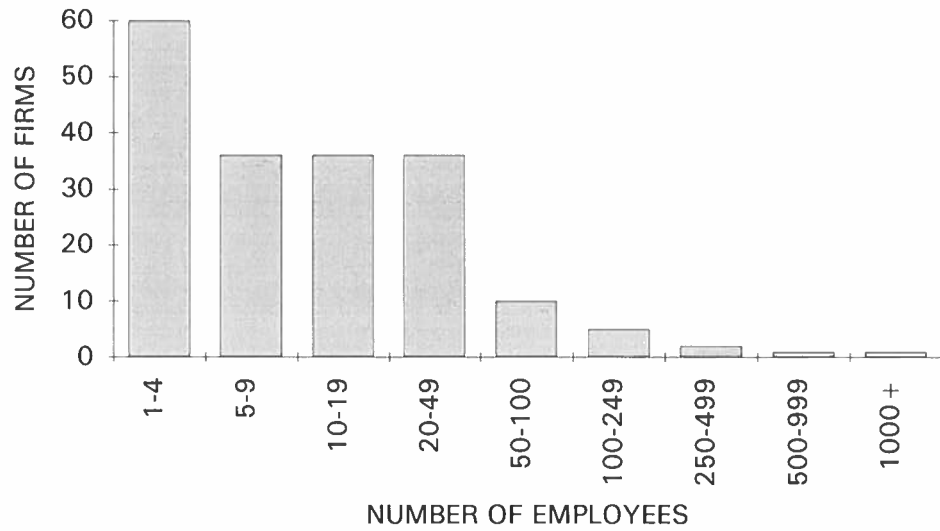
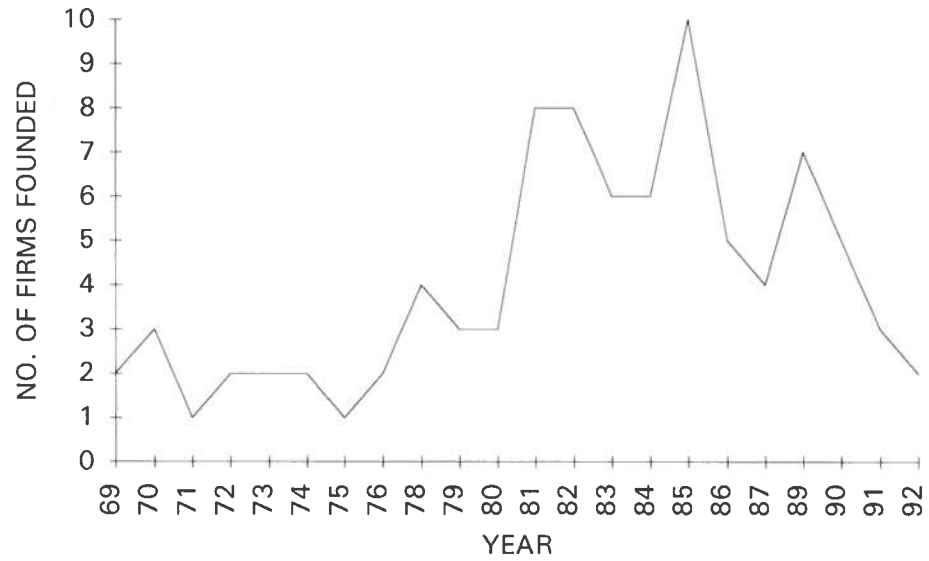FIGURE 7. DISTRIBUTION ESTIMATED SALES BY FIRM - ALL CITIES

FIGURE 8. NUMBER OF FIRMS BY CITY

FIGURE 9. YEAR OF FIRM FORMATION - ALL CITIES

FIGURE 10. TOTAL EMPLOYMENT BY CITY
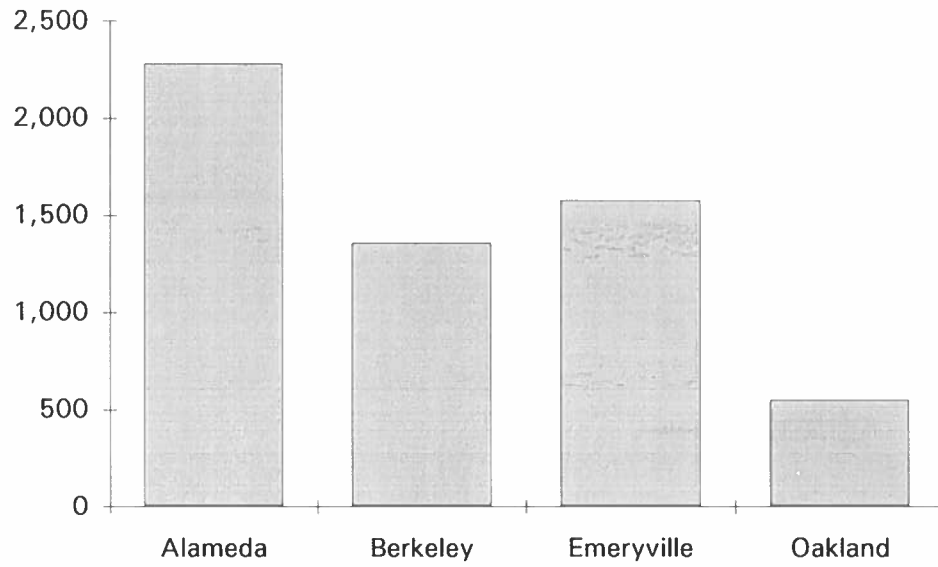
FIGURE 11. TOTAL REVENUE BY CITY

FIGURE 12. AVERAGE EMPLOYEES PER FIRM BY CITY
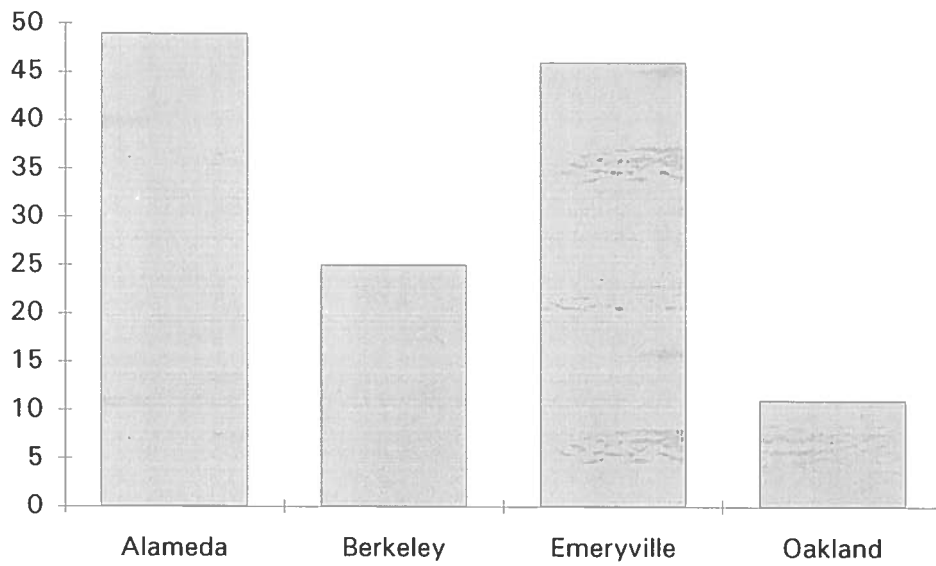
FIGURE 13. AVERAGE SALES PER FIRM BY CITY
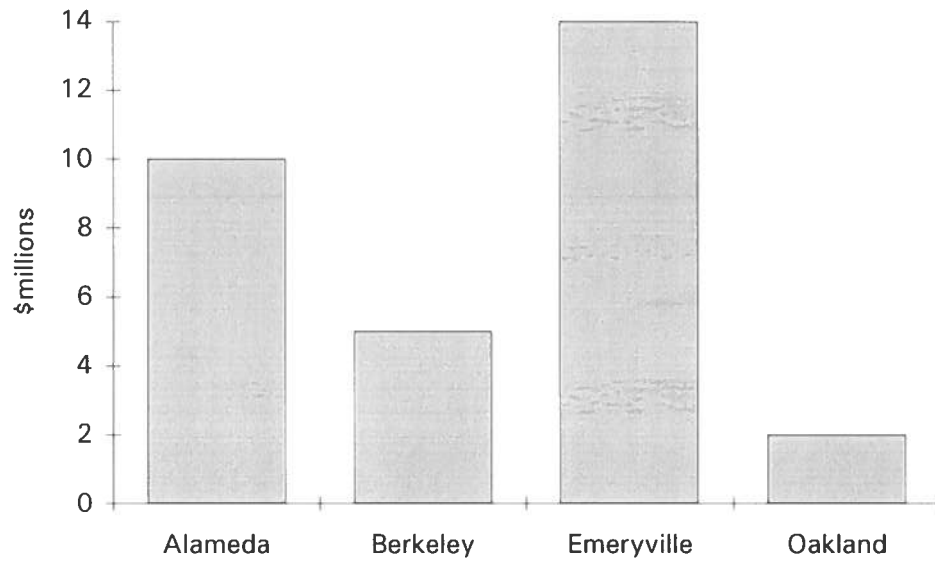
Source: software industry census by members of CP 225, Spring 1993

FIGURE 14. SHARE OF TOTAL EMPLOYMENT BY FIRM SIZE - ALL CITIES

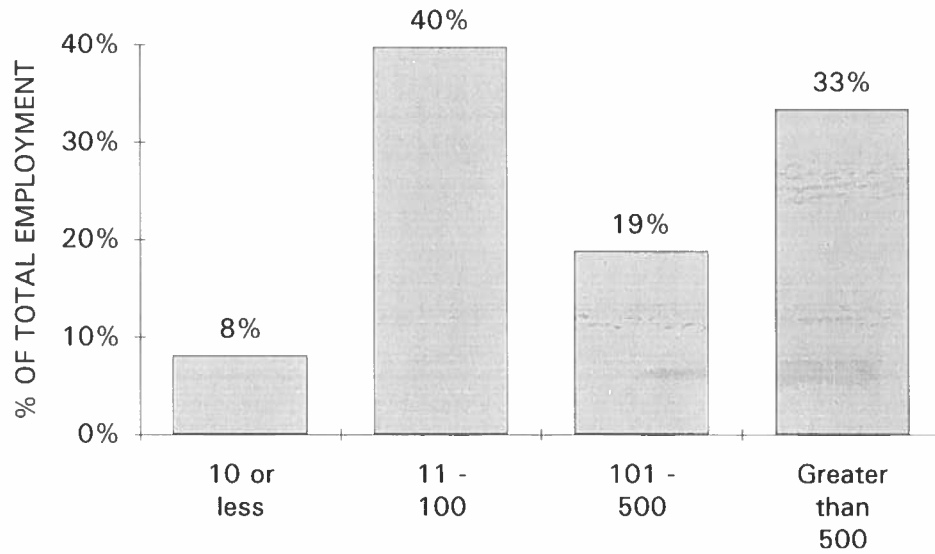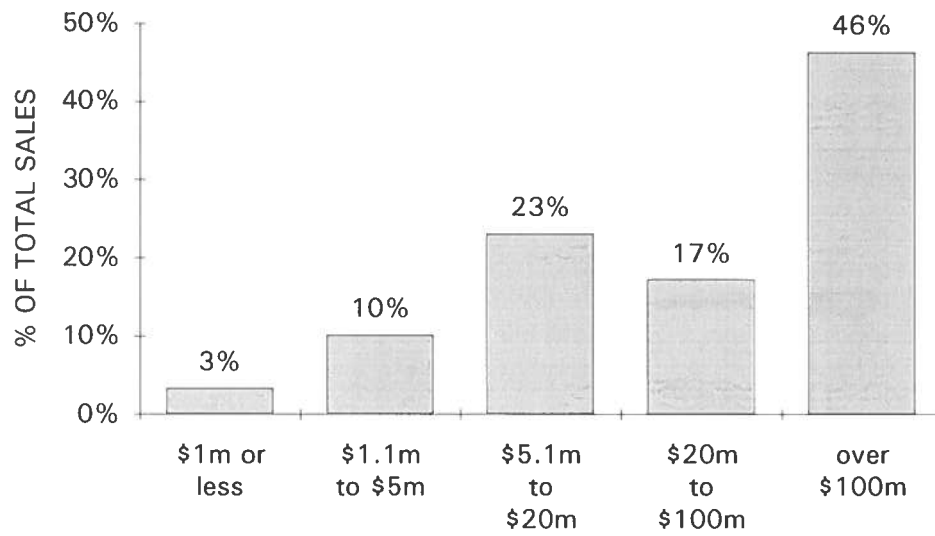## FIGURE 15. SHARE OF TOTAL SALES BY FIRM SIZE - ALL CITIES

Source: *software industry census by members of CP 225, Spring 1993*

- *An invisible industry:* Relying on their knowledge and a personal computer, a significant but largely undetectable contingent of programmers work as consultants or subcontractors for software and other firms. Even more difficult would be to assess the proportion of such labor that does not involve formal hiring and is paid "under the table."

- *Fuzzy boundaries:* Many high-technology firms engage in both manufacturing and software production, while other firms may hire programmers on a permanent basis for a variety of tasks such as database management customization of off-the-shelf equipment, or the design of data processing systems. This complicates any effort to isolate the software industry from the rest of the formal economy.

- *An effervescent industry:* The software industry is a bubbling cauldron of firm creation, boom, and bust. Directories published as recently as a year prior to the census reported many firms that no longer existed, with another large proportion of firms that had expanded into new locations. Undoubtedly, the census did not detect a number of newly created companies.

IV. Factors Contributing to the Formation and Continued Success of the Industry

Interviews provided a more complex view of the industry than quantitative analysis alone could provide. Most importantly, it provided a glimpse of the personal and institutional networks that drive the industry.

A Critical Mass of Human and Technological Resources

Much more than capital or any physical resource, knowledge is the most important commodity in software production. To this end, the University of California at Berkeley and related institutions have created a rich base of technological expertise, which is primarily responsible for the breadth and character of the regional software industry. There are several types of evidence for this relationship:

- *From ivory tower to the market:* UC Berkeley professors or graduate students have participated in virtually every major regional software startup, including Teknekron, Sybase, and Farallon. The founders of these firms chose locations in the vicinity of the university so they could maintain contact with the academic environment, drawing on the advanced research and potential labor pool found there. Students also organized the Berkeley Macintosh Users' Group, which has spawned 12 local firms since its inception.

- *The university as magnet:* Besides retaining many direct spinoffs within its orbit, the university's resources also influence many firms to locate nearby. This is particularly important for small firms who are facing high costs for developing new technology on their own.

- *Related institutions:* UC Berkeley has several associated local institutions that provide sources of advanced technology and expertise to software initiatives, including the International Computer Science Institute, Lawrence Berkeley Laboratory, and Lawrence Livermore Laboratory.

The Character of the Regional Software Industry

Institutional and environmental conditions help explain the dominant regional pattern of small- and medium-sized firm activity revealed in the census.

- The influence of UC Berkeley professors and students on the regional software industry has occurred in spite of institutional resistance to linkages with the commercial sector, both within the Computer Science Department and in the university administration. A lack of direct contacts with industry, combined with an emphasis on theoretical and advanced research without immediate commercial application, has tended to limit the possibilities for major firm startups. A venture capitalist distinguished between "leading edge" technologies, which are ready for profitable commercial application, and "bleeding edge" technologies, which are promising but still require substantial investment in research and development.

- Commercial technologies that *do* spin out of advanced research tend to meet equally advanced problems in industry, resulting in products limited to low-volume, specialized niche markets. For example, Lawrence Berkeley Laboratory recently announced the development of new software to identify faults in complex component systems, such as manufacturing or chemical plants or even particle detectors.

- In accordance with the nature of the product, most firms do not simply distribute a standardized software package. Rather, they work closely with clients on joint research and development and custom hardware-software solutions, always involving ongoing support and interaction.

- This type of service-oriented software production requires intimate knowledge of both technology and potential clients, in a manner far different from the knowledge needed to successfully produce and sell a high-volume, standardized product to the mass market. The latter skills are possessed by few firms in the region, as is the initial capital necessary for such production. For example, Teknekron Corporation, a leading "incubator" of new firms in the region, has shunned mass markets in favor of specialized ones. Its associated firms have focused on advanced solutions for specific information acquisition and processing problems in the insurance, financial, and utility industries, among others.

- The region's diversity, progressive politics, and urban amenities attract many people, or "weirdos" in the words of one software developer, who are highly concerned with the quality of their workplace rather than financial gain alone. This factor tends to keep firms small, where the work environment

is generally perceived more favorably. Although startups involve long hours and high financial risks, they also seem to offer an atmosphere of creative excitement and direct control over the outcome that many programmers find stimulating. As one programmer put it: "Startups have no prima donnas, no bureaucracy, a shallow organization, and no one keeping a time clock."

- Industry participants often perceive the region's stimulating work atmosphere in relation to the South Bay, where the emphasis on profitability tends to reach more stifling proportions. One programmer disdained the "business types" as those who "wear the suits, slap people on the back, tell obnoxious jokes, and cower over Japanese suppliers." Nevertheless, the opportunities provided by proximity to the recognized high technology capital in the South Bay is important to the vitality of the regional software industry.

Sustaining the Dynamic Growth of the Software Industry

Considering its present character and composition, the regional software industry seems unlikely to stabilize and consolidate in the near future. Rather, existing networks among institutions, firms, and individuals will continue to generate a diverse fabric of new technologies and startups in order to take the place of those that fail or move out of the region.

- Informal networks, although difficult to capture, are a vital sustaining influence to the software industry. Events and institutions that foster contact among industry participants both within the region and beyond may contribute to the industry's dynamism. Particularly important are contacts among software programmers and engineers, and the entrepreneurs who can develop their expertise into successful ventures.

- As growing firms seek more space and a better business climate, they tend to move from Berkeley to Alameda, Emeryville, and Oakland. Business parks in Alameda, office high-rises in Emeryville, and low-rent Oakland neighborhoods have all enticed larger firms to move out of Berkeley, including Farallon, Ingres, and TRW Financial Systems. These firms also have developed their own contacts and resources, and thus depend less on proximity to regional institutions such as UC Berkeley. Because of the political and spatial limitations on firm growth in Berkeley, it seems likely to continue its role as an "incubator" for the smallest new firms which will eventually move out if they succeed and grow. As mentioned above, the largest firms tend to move out of the region altogether.

V. Limitations on the Software Industry as an Engine for Economic Development

Even if northern Alameda County proves to be the "Silicon Valley of software," the software industry has grave limitations as an engine of economic growth.

- Limitations on space and environmental quality limit the chance of forming a stable core of large firms to anchor the regional industry, leaving new, small firms to dominate the industry's dynamics. Economic planning that accounts for such volatility will be difficult.

- Approximately three-quarters of the jobs created by software firms require extensive training in computer science or engineering, thus excluding most of the local population from these jobs. At best, employment training programs can prepare people for clerical and data processing jobs involving computers.

- Because the goods and services required by software firms are minimal, the economic multiplier effect of the industry is undoubtedly less than in most other manufacturing or service sectors.

- Ultimately, the dynamics of the software industry seem intimately tied to the urban fabric of the region itself. All plans and policies that affect the urban quality of life in the region, relating to issues such as urban design and amenities, transportation, and social services, will have an impact on the attractiveness of the region for software firms.