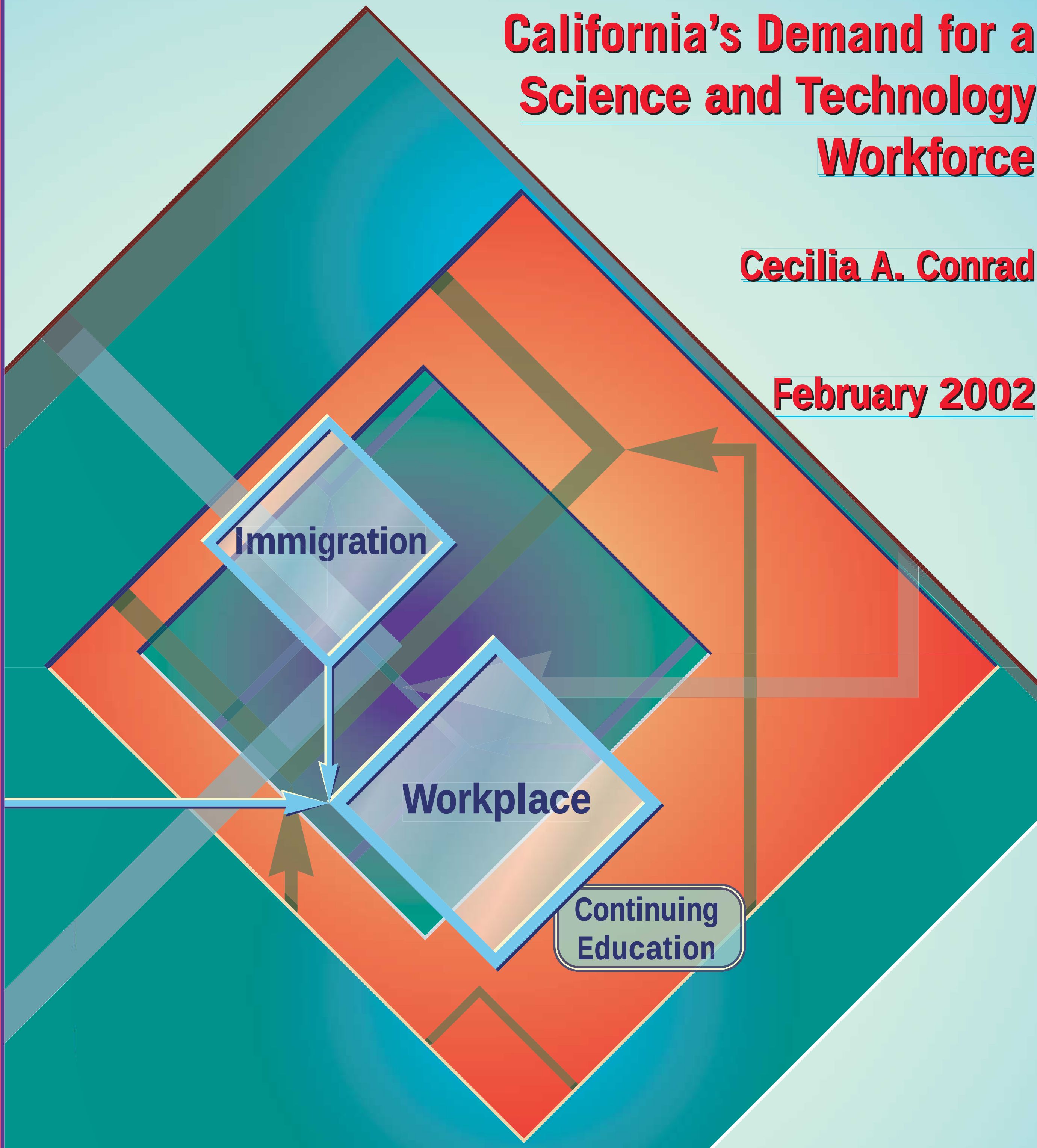
Critical Path Analysis of California's S&T Education System:

California's Demand for a Science and Technology Workforce

Cecilia A. Conrad

February 2002



CALIFORNIA COUNCIL ON SCIENCE AND TECHNOLOGY

California's Demand for a Science and Technology Workforce

A Report Prepared for

The California Council on Science and Technology

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February 2002

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1. INTRODUCTION

From March 2001 to May 2001, the number employed in California's communications equipment industry decreased by 2.3%; the number employed in electronic components manufacturing decreased by 1.8%; and the number employed in computer programming services decreased by 0.2%. In this environment, one might forget that just a year ago employers complained of a shortage of skilled labor and lobbied Congress for expansion of the H-1B visa program to expand recruitment of workers from overseas. Yet, California's science and technology sector still employs a large number of workers and the long-term trend in employment is positive. Furthermore, although complaints of shortages of skilled labor have receded, they are unlikely to disappear completely. Employers have complained periodically about a deficit of skilled science and technology labor since at least the 1950s. Examining these complaints in 1959, economists Kenneth Arrow and William Capron concluded that the shortages of scientists and engineers reflected the lag between a shift in demand and a shift in supply. (Arrow and Capron, 1959) The market works, they argued. It just takes time. Lerman (1998) and Conrad(1999) reached similar conclusions about the contemporary labor market for science and technology workers.

This paper is part of larger study of the factors that contribute to this lag between shifts in demand and shifts in supply -- the California Council on Science and Technology's Critical Path Analysis Project. The other components of this critical path analysis examine bottlenecks in formal education. This paper focuses on what happens once formal education is complete. It asks four questions. What is the level and geographic distribution of employment? What is the trend in employment and earnings? What are the required skills? What obstacles, if any, delay adjustment to equilibrium or lead to an inefficient allocation of labor resources?

THE PRINCIPAL FINDINGS ARE:

- Over 1.5 million Californians work in the high tech sector. Although employment growth has slowed in recent months, the long term trend is positive.
- The geographic distribution of science and technology employment in California is uneven. Hence, demand and skills needed may vary across the state.
- High tech jobs are high paying. Between 1997 and 1999, both employment and average annual payroll grew dramatically in computer related industries. Employment growth has slowed in recent months.
- Science and technology sector requires a highly skilled labor force. Nearly 30% of jobs in this sector require a bachelor's degree. Over 40% of jobs require some post-secondary education. Jobs require basic skills in mathematics as well as knowledge of specific operating systems and programming skills.
- Employers have used the H-1B visa program to hire workers with higher levels of educational attainment than domestic workers in the same jobs have. This program probably eased the tight labor market conditions at the end of the 90s. There is uncertainty surrounding the fate of these workers during periods of slack demand.
- Women of all races, African American men and Latino men represent underutilized pools of labor in the science and technology sector. Differences in educational attainment and in choice of major (women) contribute to their under-representation in science and technology occupations and industries, but don't explain differential rates of unemployment.

2. THE SIZE AND GEOGRAPHY OF CALIFORNIA'S SCIENCE AND TECHNOLOGY SECTOR

Table 2.1 reports the number of high tech jobs nationwide and in California in 2000.[1] High tech jobs represent approximately 11.4% of total employment in California.

California's share of U.S. science and technology employment is larger than its share of total employment. California's share of total U.S. employment has hovered near 11% for the past 20 years while its share of U.S. science and technology employment has ranged from 15-18% over the same period. Furthermore, the decline in California's share of U.S. science and technology employment reported in the 1999 CREST Report appears to have ended. (Conrad, 1999) California's share of U.S. S&T employment declined from 17% in 1989 to 15% in 1998, but increased to 16.6% in 2000.

The statistics cited above come from the Bureau of Labor Statistics' monthly establishment survey, Current Employment Statistics (CES). The CES is a sample of nearly 400,000 establishments that employ roughly 1/3 of payroll workers. Another source of data on the size of California's science and technology sector is the Economic Census. The U.S. Bureau of the Census conducts a comprehensive survey of U.S. firms once every five years. This survey is mailed to over 5 million companies who, by law, are required to reply. In addition to total employment, the survey collects data on annual payroll and number of establishments at all geographic levels. Because of its comprehensiveness, the Economic Census permits a more detailed breakdown of data.

The most recent economic census was conducted in 1997.[2] The 1997 Economic Census replaces the standard industrial classification system (SIC) (used to categorize industries in the BLS) with the North American Industry Classification System (NAICS). The NAICS classification system offers a more refined definition of some science and technology industries than the old Standard Industrial Classification (SIC) code. Industries defined using the NAICS system more closely correspond to the categories defined by CCST. For example, the SIC classification system groups manufacturing of computers with manufacturing of other office equipment including pencil sharpeners. The relevant three-digit category is 357. Under the NAICS, the manufacture of computers falls under the three-digit code 364 while pencil sharpeners falls into a separate category 339. NAICS also allows distinctions between software publishers and data processing services and between computer systems design and other research and testing services.

Table 2.2 reports total employment in science and technology industries nationwide and in California using the Economic Census data. Using this data, there are 907,108 employees in the science and technology sector in California, representing 8.9% of total employment in the state. The number of jobs is slightly smaller than reported using Bureau of Labor Statistics data because the NAICS categories allow a more refined definition of the science and technology sector. Using the NAICS data, California's share of U.S. high tech jobs is just over 18% (comparable to the statistic from the BLS data). Its share of employment, all sectors, is 15% (higher than indicated by BLS data).[3]

Science and technology employment is not evenly distributed across the state. Table 2.3

1 The California Council on Science and Technology defines the science and technology sector to include biotechnology and biomedical; software and computer related services and entertainment; computer and electronic equipment; telecommunications; and aerospace.

2 The data began to be released in Spring 2000.

3 Appendix Table A-1 uses the 1997 Economic Census data to compare science and technology employment in California with that in selected other states.

uses Economic Census data to compare the distribution of employment in selected industries across the state. Employment in communications equipment and computer manufacturing is concentrated in Silicon Valley. According to the 1997 Economic Census, over 48% of computer manufacturing jobs and over 51% of communications equipment manufacturing jobs are located in the San Jose region. Software publishing is also concentrated in northern California while data processing services and on-line information services are evenly divided between north and south. Los Angeles hosts 30% of employment; Orange County, 13%. This geographic concentration of industries has implications for labor demand because of variations in skill requirements within the science and technology sector.

Table 2.1
High Tech Jobs, 2000, United States and California

Industry	All U.S. Jobs	All California Jobs	All California % of U.S.
Pharmaceuticals	305,200	39,600	12.98%
Computer Manufacturing	363,200	95,000	26.16%
Communications Equipment	270,800	42,000	15.51%
Electronic Components	667,000	163,200	24.47%
Aircraft & Missiles	546,900	96,500	17.64%
Scientific Instruments	846,600	178,600	21.10%
Communications	1,612,000	195,800	12.15%
Computer Programming	1,941,200	370,600	19.09%
Engineering & Management Services	3,413,200	468,700	13.73%
Total of High Tech Shown Here	9,966,100	1,650,000	16.56%
Total Private Nonfarm Jobs	131,418,000	14,518,600	11.05%
High Tech As % of Total Private Nonfarm Jobs	7.58%	11.36%	

Source: http://www.bls.gov/sahome.html, via links for "National Employment, Hours, and Earnings," and "State and Area Employment, Hours, and Earnings," retrieved 3/20/01-3/28/01.

Table 2.2
High Tech Jobs, 1997 Economic Census

Industry	All U.S.	California	% of U.S.
Aerospace	488,055	102,956	21.10%
Computers & Electronic Products	1,698,529	396,482	23.34%
Software Publishers	266,380	77,277	29.01%
Online Information Services	49,935	9,822	19.67%
Data processing Services	262,250	20,679	7.89%
Computer Systems Design	764,659	101,494	13.27%
Scientific Research & Development in Physical, Engineering & Life Sciences (taxable only)	161,304	37,347	23.15%
Telecommunications	1,010,389	116,253	11.51%
Pharmaceuticals	203,026	27,022	13.31%
Basic Chemical Manufacturing	202,486	5,795	2.86%
Testing Laboratories	82,024	11,981	14.61%
Total S&T	5,189,037	907,108	17.48%
All Sectors	66,751,363	10,153,844	15.21%

Source: U.S. Economic Census, www.census.gov, retrieved Jan-March 2001.

Table 2.3
Geographic Distribution of Science and Technology Employment in California
Number of Paid Employees, 1997

NAICS Code	3341	3342	3343	3344	3345	3346	5112	514191	5142	5415
	Computer & Peripheral Equipment	Communications Equipment Manufacturing	Audio & Video Equipment	Semiconductor & Other Electronic Components	Navigational, Measuring, Medical & Control Instruments	Manufacturing & Reproducing Magnetic & Optical Media	Software Publishers	Online Information Services	Data Processing Services	Computer Systems Design
California	68,527	71,160	5,635	140,480	93,509	17,171	77,277	9,822	20,679	101,494
San Jose	32,876	36,058	631	64,795	28,054	4,164	22,708	2,157	1,256	19,195
San Diego	8,192	5,064	274	7,465	9,381	449	4,483	974	2,065	8,789
Los Angeles/ Long Beach	2,796	12,494	1,999	17,889	23,300	3,120	7,595	2,952	6,111	22,540
Orange Co.	8,208	3,179	1,449	22,970	11,359	2,218	5,857	749	2,751	11,446
Oakland	2,979	3,182	NA	7,247	5,364	5,047	11,076	713	1,160	11,203
San Francisco	444	3,083	NA	2,426	3,842	NA	17,128	1,443	2,257	14,963
Other California	13,032	8,100	1,282	17,688	12,209	2,173	8,430	834	5,079	13,358
In Percent										
California	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
San Jose	47.98%	50.67%	11.20%	46.12%	30.00%	24.25%	29.39%	21.96%	6.07%	18.91%
San Diego	11.95%	7.12%	4.86%	5.31%	10.03%	2.61%	5.80%	9.92%	9.99%	8.66%
Los Angeles/ Long Beach	4.08%	17.56%	35.47%	12.73%	24.92%	18.17%	9.83%	30.05%	29.55%	22.21%
Orange Co.	11.98%	4.47%	25.71%	16.35%	12.15%	12.92%	7.58%	7.63%	13.30%	11.28%
Oakland	4.35%	4.47%	NA	5.16%	5.74%	29.39%	14.33%	7.26%	5.61%	11.04%
San Francisco	0.65%	4.33%	NA	1.73%	4.11%	NA	22.16%	14.69%	10.91%	14.74%
Other California	19.02%	11.38%	22.75%	12.59%	13.06%	12.66%	10.91%	8.49%	24.56%	13.16%

NA -- Data are not reported for industries with less than 250 employees.

3. TRENDS IN EMPLOYMENT AND EARNINGS

Figure 3.1 describes employment in California's science and technology sector from 1972-2000. Employment decreased between 1987 and 1994, but then increased rapidly. The data are not continuous. In particular, before 1988, engineering and management services is not listed as a separate category. Before 1996, the employment numbers for computer programming services are estimates based on the assumption that computer programming services share of total business service employment was the same in California as in the nation. Given the high proportion of computer programming service employment located in California, the pre-1996 data probably understate employment in this category. The gold/dashed line shows the trend in employment for industries with data available over the entire period.

Figure 3.2 describes the employment growth by industry. Computer programming was the fastest growing sector between 1995 and 1999 while the aerospace sector lost jobs during this period. Employment growth in California's science and technology sector has been above average, despite the continued decline in aerospace.

Figure 3.3 presents projections of occupational employment growth in California. These projections pre-date the recent economic slowdown and hence, are likely to be overly optimistic. The number of computer support specialists is projected to grow by 90% and the number of computer engineers, by 76% through 2008. A few computer-related occupations will shrink according to these projections. For example, the number of computer operator jobs is projected to decline by 5,400. Notably, the shrinking occupations tend to be those that require less formal training or education.

High tech jobs are high paying. Table 3.1 describes annual average wages in the high tech sector in 1999. Annual wages in California's science and technology industries averaged $73,556. Computer and office equipment manufacturing is the most lucrative for workers. The average annual wage was $119,677 compared with $37,311 for all California industries. Even the lowest paying science and technology industries — aerospace and medical instruments — offered wages considerably above the California average.[4]

Figure 3.4 examines wage growth in the science and technology sector. In the 1999 CREST report, the evidence on wage growth was mixed (Conrad, 1999). Wage growth in the science and technology sector averaged 17.9%. By comparison, average annual wages in all industries increased by 7% between 1995 and 1999. The most dramatic wage growth occurred in computer equipment manufacturing where annual payroll per worker grew by 38.6%. Wages in computer programming services grew by nearly 20%.

Two Silicon Valley employers, Cisco and Hewlett-Packard, have recently announced layoffs. These announcements coupled with a slow down in employment growth presage less tightness in the science and technology labor market. Table 3.2 reports monthly employment data for California's science and technology sector from March 2000 to March 2001, employment growth was close to zero percent in most high tech industries. (See Table 3.2.) The long term projection for employment in California's science and technology occupations is positive, but this recent trajectory underscores the need for caution in assessing those estimates.

The 1999 CREST report debated whether there was a "dynamic shortage" of skilled science and technology labor. (Conrad,1999) A dynamic shortage occurs when there is a time lag between an increase in demand and the

4 Appendix Table A-2 uses the economic census data to calculate annual average payroll for California and a group of comparison states.

supply response. Veneri (1999) identifies three indicators of a dynamic shortage: above normal employment growth, historically low unemployment rates; and higher than average wage growth. From 1995-1997, the period studied by the 1999 CREST report, California's science and technology sector was experiencing above average employment growth and unemployment rates across all sectors were historically low, but the evidence on wage growth was mixed. Some industries with high rates of employment growth experienced modest growth in wages. Other industries experienced above average growth despite a decline in employment. For the period, 1997-1999, there is stronger evidence of a dynamic labor shortage but, if recent employment figures are a guide, this shortage may not persist.

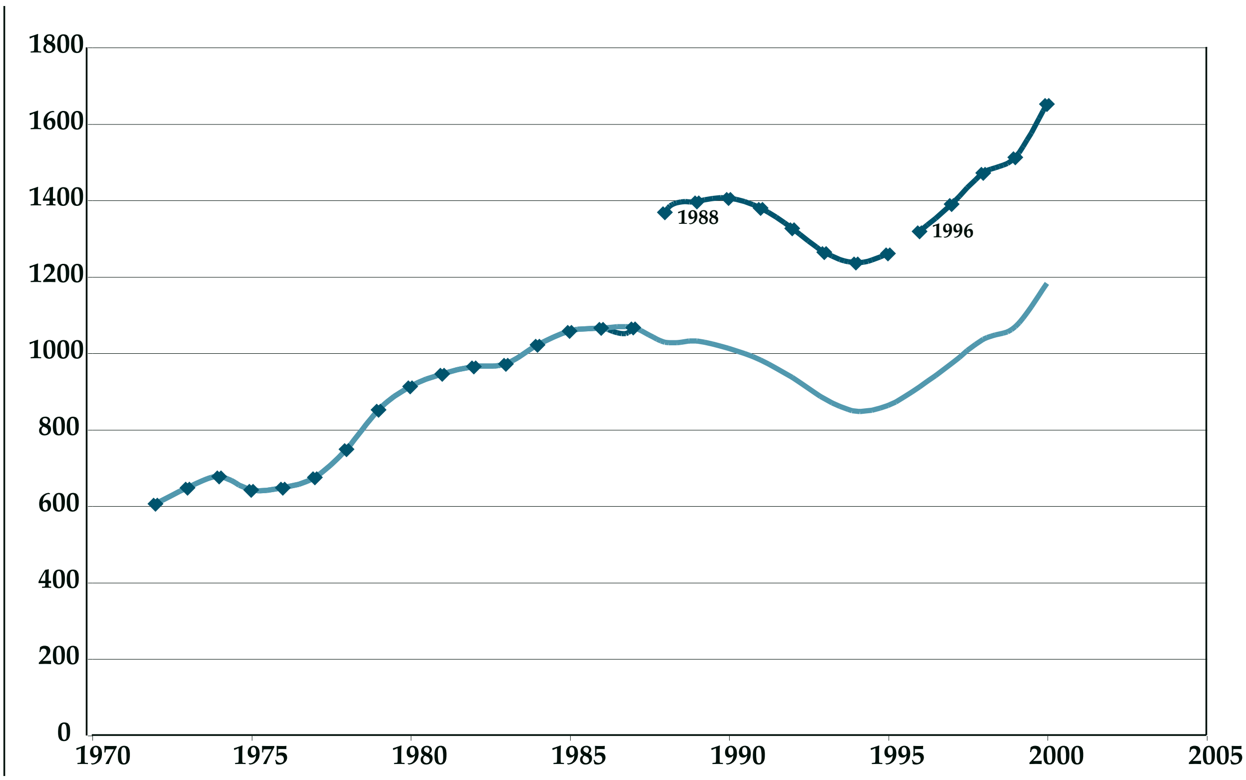


Figure 3.1 -- High-tech Employment in California, 1972-2000

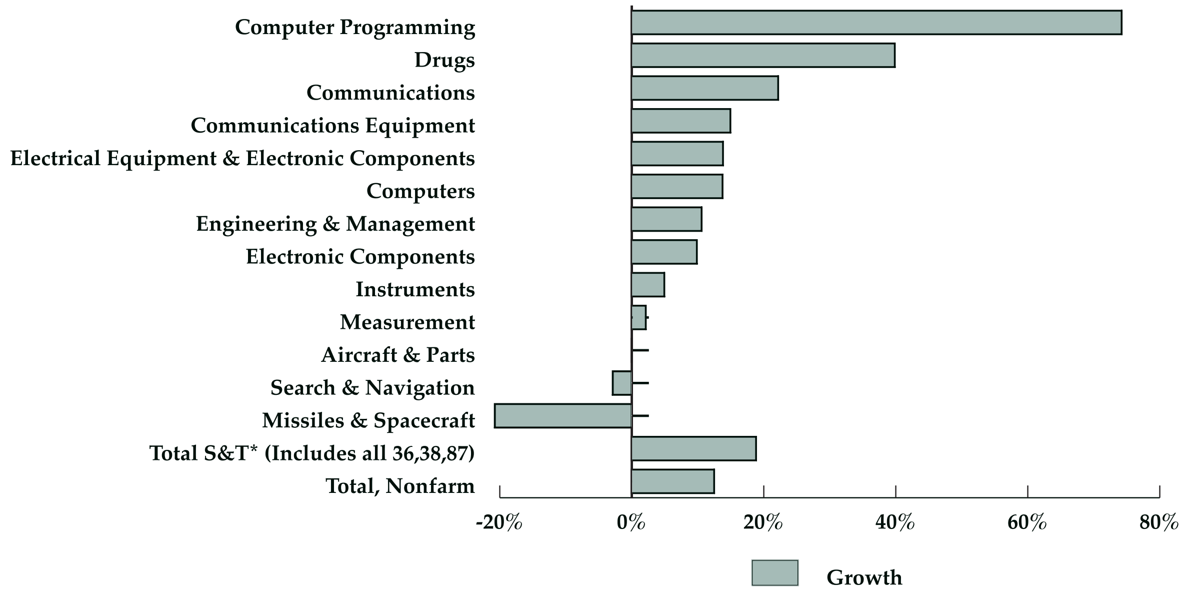


Figure 3.2 -- Employment Growth in California's Science and Technology Sector, 1988-2008

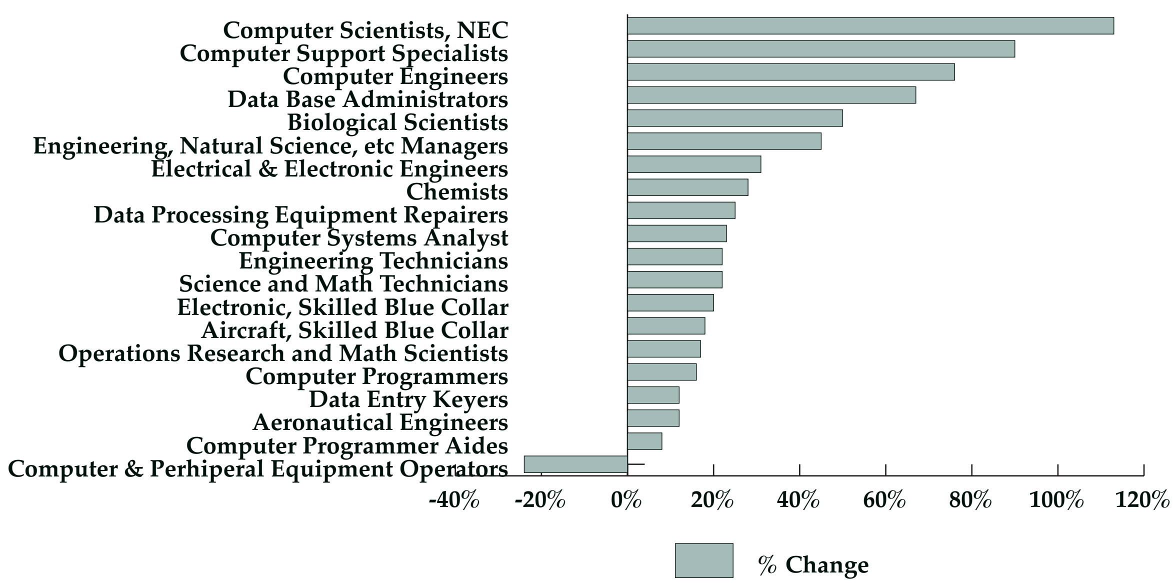
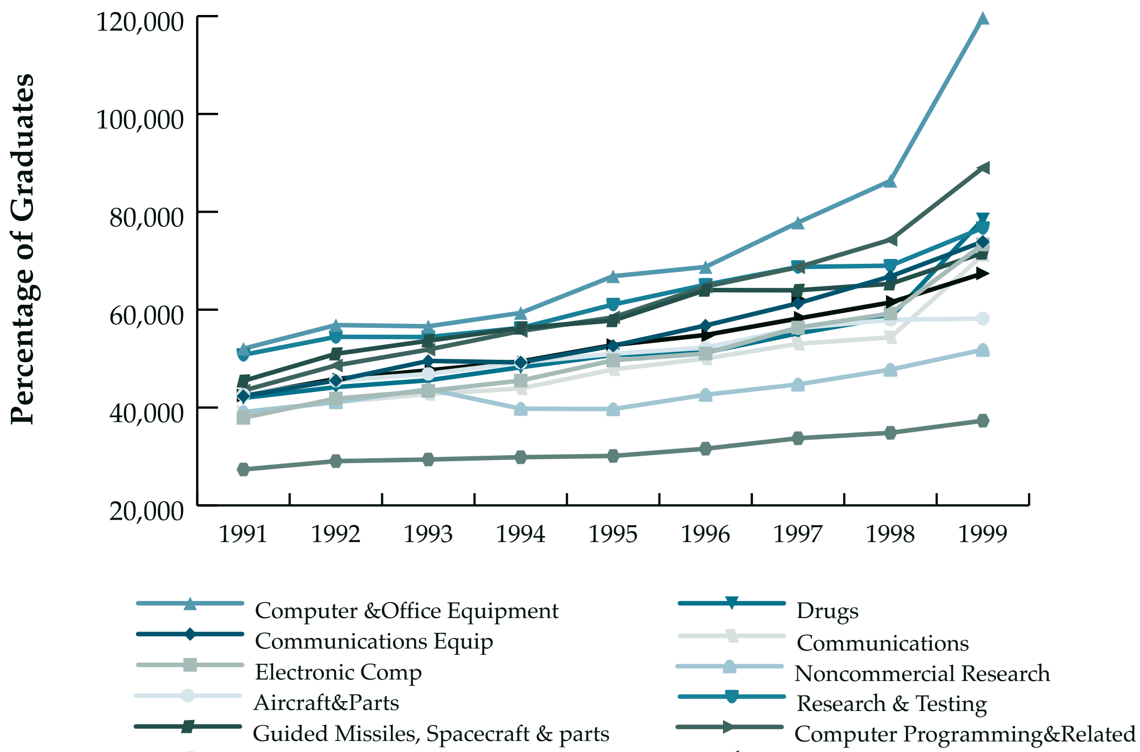


Figure 3.3 -- Projected California Employment Growth in Selected S&T Occupations



Source: National Science Foundation, *Science and Engineering Indicators 2000*, www.nsf.gov/sbe.seind00/access/toc.htm, Appendix Table 3-1.
Figure 3.4 -- Growth in Average Annual Payroll

Table 3.1
Annual Average Wages in California High Tech Industries

SIC		1991	1992	1993	1994	1995	1996	1997	1998	1999	Wage Growth 1991-97	Wage Growth 1991-94	Wage Growth 1995-97	Wage Growth 1997-99
357	Computer & Office Equipment	$52,035	$56,853	$56,601	$59,347	$66,849	$68,737	$77,818	$86,348	$119,677	49.6%	14.1%	16.4%	38.60%
366	Communications Equipment	$42,355	$45,535	$49,524	$49,233	$52,624	$56,767	$61,312	$66,796	$73,907	44.8%	16.2%	16.5%	10.65%
367	Electronic Components	$37,901	$41,837	$43,400	$45,512	$49,649	$51,039	$56,340	$59,228	$73,335	48.7%	20.1%	13.5%	23.82%
372	Aircraft & Parts	$42,573	$45,479	$46,883	$49,181	$50,983	$52,258	$56,231	$57,940	$58,166	32.1%	15.5%	10.3%	0.39%
376	Guided Missiles, Spacecraft & Parts	$45,449	$50,981	$53,651	$56,276	$57,782	$64,007	$63,961	$65,291	$71,584	40.7%	23.8%	10.7%	9.64%
38	Instruments	$42,454	$45,846	$47,610	$49,417	$52,775	$54,830	$58,198	$61,473	$67,408	37.1%	16.4%	10.3%	9.65%
737	Computer Programming & Related	$43,470	$48,602	$51,846	$55,645	$58,431	$64,719	$68,678	$74,290	$88,995	58.0%	28.0%	17.5%	19.79%
8731	Research & Testing	$50,775	$54,444	$54,420	$56,273	$61,054	$65,096	$68,737	$68,991	$76,708	35.4%	10.8%	12.6%	11.19%
8733	Noncommercial Research	$39,098	$41,120	$43,733	$39,769	$39,685	$42,620	$44,726	$47,760	$51,809	14.4%	1.7%	12.7%	8.48%
48	Communications	$38,929	$41,074	$42,770	$43,907	$47,784	$50,013	$53,028	$54,341	$71,168	31.5%	15.0%	8.7%	30.97%
283	Drugs	$41,954	$44,169	$45,564	$48,228	$50,744	$51,250	$55,162	$58,464	$78,432	31.5%	15.0%	8.7%	34.15%
	All Industries	$27,340	$29,043	$29,377	$29,849	$30,108	$31,587	$33,724	$34,836	$37,311	23.4%	9.2%	12.0%	7.10%

Source: State of California, Economic Development Department, Unpublished ES2O2 Data.

Table 3.2
Recent Employment in California's High Tech Sectors

	MAY 00	JUN 00	JUL 00	AUG 00	SEP 00	OCT 00	NOV 00	DEC 00	JAN 01	FEB 01	MAR 01	APR 01	MAY 01	1-yr Chg	1-yr Chg %	3 -mo Chg	3-mo Chg %
Communications Equipment	41.7	42.4	42.4	42.5	42.6	43.0	43.3	43.5	43.5	43.2	42.9	42.6	41.9	0.2	0.5%	-1.0	-2.3%
Electronic Components	160.0	164.3	165.3	166.2	167.1	167.9	168.2	168.5	167.9	167.6	167.0	165.5	164.0	4.0	2.5%	-3.0	-1.8%
Computer Equip Manufacturing	95.3	95.8	96.5	96.1	95.2	94.8	94.8	94.7	94.2	94.0	93.8	93.9	93.8	-1.5	-1.6%	0.0	0.0%
Search & Navigation Equipment	48.6	48.6	49.1	48.8	48.2	48.5	48.4	48.2	48.1	48.4	48.8	48.8	48.8	0.2	0.4%	0.0	0.0%
Measuring & Control Devices	67.2	68.2	69.4	69.9	69.8	70.3	70.8	71.2	71.3	72.1	71.5	71.2	71.2	4.0	6.0%	-0.3	-0.4%
Other Instruments & Related	61.1	61.4	61.7	62.0	62.3	62.6	62.8	63.0	63.0	63.0	63.1	63.0	62.7	1.6	2.6%	-0.4	-0.6%
Total Scientific Instruments	176.9	178.2	180.2	180.7	180.3	181.4	182.0	182.4	182.4	183.5	183.4	183.0	182.7	5.8	3.3%	-0.7	-0.4%
Drugs	39.4	39.7	40.0	39.9	39.8	40.0	40.1	40.3	40.4	40.5	40.6	40.7	40.8	1.4	3.6%	0.2	0.5%
Computer Programming & Related Services	370.8	381.8	383.0	383.8	385.3	387.5	391.7	396.2	398.2	401.6	403.5	404.5	402.7	31.9	8.6%	-0.8	-0.2%
Engineering & Management	468.6	477.2	477.1	476.6	475.5	475.8	478.3	480.9	467.9	473.8	476.1	477.0	477.7	9.1	1.9%	1.6	0.3%

Source: U.S. Bureau of Labor Statistics, www.bls.gov.

4. DEMAND FOR SKILL

High tech jobs are high paying because they require a highly skilled workforce. Table 4.1 provides a count of occupational employment sorted by minimum educational requirement as defined by the Bureau of Labor Statistics. Forty-one percent of jobs in California's science and technology industries require a bachelor's degree or higher; for 23% of those, a bachelor's degree or higher in a science and engineering field is preferred. Jobs that require an associates degree account for another 5% of employment. The most skill intensive industries are Computer and Data Processing Services[5], Search and Navigation Equipment, and Guided Missiles and Parts.

According to projections, the demand for persons with bachelor's degrees in science and engineering will continue to grow. Table 4.2 reports projected employment growth from 1998-2008 for California's science and technology industries. As in Table 4.1, occupations are grouped by minimum educational requirement. Figure 4.1 summarizes this data. The largest job growth is projected in occupations that require at least a bachelor's degree in a science and engineering field. Again, in the current economic environment, projections of occupational growth based on historical trends are likely to be inaccurate.

Although high tech employers do hire persons without degrees in science and engineering, especially in a tight labor market, the majority of science and technology professionals earned their highest degree in a science and engineering field.[6] According to National Science Foundation data, 91.3% of employed U.S. scientists and engineers have earned at least one degree in a science and engineering field. Eighty-four percent earned their highest degree in a science and engineering field. Figure 4.2 describes the distribution of persons employed as scientists and engineers by S&E degree status in 1997.

As noted above, in tight labor markets, employers will hire persons with degrees outside of science and engineering. This practice is most prevalent in information technology occupations. Figure 4.3 reports the percentage of persons employed in specific science and engineering occupations who do not have their highest degree in a science and engineering field. Computer and math scientists are most likely to include persons without science and engineering degrees. Nearly 23% of computer and math scientists earned their highest degrees in non S&E fields. An additional 10% earned their highest degree in social and related sciences. Many computer and math scientists earned their highest degrees in other science and engineering fields. According to NSF data, 17% of the computer and math scientists earned their highest degree in engineering; 6.9% in life, physical and related sciences. Less than half of computer and math scientists earned their highest degree in computer and math sciences. In contrast, 74% of persons employed as life scientists earned their highest degree in life sciences; 73% of physical scientists earned their highest degree in physical sciences; and 77% of engineers earned their highest degree in engineering.

Although workers without formal education in computer science may find employment, there are likely to be limitations on the tasks they perform. The National Academy of Science, *Building a Workforce for the Information Economy*(pp. 48-49), segments IT work into two categories.

5 A survey of San Diego's Software and Computer Services cluster suggests an even more highly educated workforce than reported here. In the San Diego study, 48% of employees have Bachelor's degrees and 27% have a Master's degree. (San Diego Workforce Partnership, 2000)

6 The NSF counts social sciences such as economics or psychology as science and engineering fields.

"Category I work involves the development, creation, specification, design and testing of an IT artifact, or the development of system-wide applications or services; it also involves IT research.... Category 2 work primarily involves the application, adaptation, configuration, support, or implementation of IT produces or services designed or developed by others."

Persons without degrees in computer science are more likely to be hired in Category 2 jobs than in Category 1 jobs.

This report also creates a two by two typology of knowledge required for IT work. Skills were categorized as hard (technological) or soft and then as enduring or perishable. Enduring, hard skills include logical reasoning and the ability to apply algorithms to solve problems.[7] Perishable, hard skills include knowledge of particular hardware or software languages or systems. Enduring, soft skills include communication skills and the ability to learn; a perishable soft skill is knowledge of a particular company or industry. These findings for the information technology are likely to hold for other science and technology sectors as well. Although some skills may be acquired through a variety of post secondary education experiences, others require specific technical training or certification.

4.1 USE OF IMMIGRANT LABOR

The popularity of the H-1B visa program is one indicator of the slow adjustment of domestic supply to changes in demand. The H-1B visa program allows a skilled foreign person to work for a maximum of six years in the United States. The H-1B visa holder must be in a "specialty occupation" -- one that requires both the theoretical and practical application of a body of highly specialized knowledge and attainment of a bachelor's degree or higher in the specialized field. Although the H-1B visa program is not the only means of entry for skilled immigrants[8], backlogs in the processing of permanent visa applications have increased the attractiveness of the program. Employers may obtain an H-1B visa for a worker and then apply for a permanent employment visa. The program is costly for employers. In addition to the direct fees paid to the government, there are the legal costs associated with making the case for a visa.

Before 1999, the upper limit on H-1B visas was 65,000 workers a year. In 1999 and 2000, the limit was raised to 115,000 workers a year. Approximately 134,000 workers were approved for H-1B visa status between May 1998 and June 1999. (INS, 2000) Figure 4.4 describes the distribution of approved petitions by occupation. Approximately 60% of approved petitions were for workers in computer related and engineering occupations. Lowell (2000) estimates that the number of H-1B visa holders in 2001 is 500,000. If 60% are in science and engineering occupations (300,000), H-1B visa holders would only represent less than 1 percent of total employment in this sector.

Information on H-1B visa holders is scarce.[9] The Immigration and Naturalization Service (INS) initiated a sample survey of H-1B visa petitions just three years ago, but the data collected is limited to information reported on the employer's petition. In particular, it is not possible to sort H-1B visa holders by geographic location.[10]

7 A partial list of perishable, hard skills in high demand in the California's information technology sector, based on surveys of information technology workers and employers in the San Diego area and in Silicon valley, includes: Unix, Novell, Windows NT, SAP, Oracle, C/C++, Java, SQL, and Visual Basic.

8 Lowell (2001, pp. 3-4) provides a convenient summary of the different classes of admission.

9 In general, there is a problem estimating the stock of H-1B visa holders in the country at any point in time. INS measures only the flow of workers. Lowell (2001) offers a thorough description of the data limitations regarding all immigrant labor.

10 The INS does publish a list of employers with more than 50 H-1B visa petitions, but employers on this list may have locations in multiple states. In addition, a nontrivial percentage of H-1B visa holders are employed through intermediaries, personnel supply firms. The employer may be based in California, but the worker in Virginia.

To learn more about the characteristics of H-1B visa holders, we conducted a mail survey of H-1B visa holders employed by a information technology consulting and personnel supply firm based in Northern California. Out of 100 surveys mailed, 27 were returned. Table 4.3 summarizes basic information about the respondents and the distribution of the H-1B visa holders by job title, type of company and specific software skills. Most of this group, like the majority of H-1B visa holders, were born in India. Sixteen of the 27 respondents were based in California.

As would be expected given the rules of the program, the H-1B visa holders tend to be better educated than the science and technology workforce as a whole. In addition to the high proportion with masters degrees, most reported facility in two or more software languages or systems. This sample is too small to make sweeping conclusions, but the findings bolster the conclusion that high tech jobs require a high level of skill.

A third source of information on immigrant labor is the U.S. Current Population Survey. The U.S. Current Population Survey is a monthly survey of a national sample of households. It has information on citizenship status and year of arrival in the United States, but it does not have information on visa status. Nevertheless, it is possible to draw some inferences about H-1B visa holders by examining recent immigrants in skilled occupations. Table 4.4 describes the demographic characteristics of California's engineers, computer and math scientists, natural scientists, and engineering and science technicians by citizenship status and year of arrival in the U.S. since 1994. Non-citizens are slightly better educated than citizens. The most recent immigrants are more likely than any other group to have a doctorate degree.

Table 4.4 also describes the composition of these occupations by immigrant status. Sixteen and one-half percent of engineers are non-citizens and 9% are potentially H-1B visa holders; 21.6% of computer and math scientists are non-citizens and 14.7% are potentially H-1B visa holders. Among industries, computer manufacturing hosts the largest percentage of recent immigrants.

The characteristics of workers admitted under the H-1B visa program are consistent with other information regarding employer demand for skill. Employers are using the program to hire workers with slightly higher levels of educational attainment than their domestic workforce; they are using the program to hire workers with knowledge of specific software and programming languages; and they are using the program to hire workers with degrees in computer science or other technical fields. Lowell (2001) estimates that a fifth of job openings for computer and math scientists are being filled by foreign-born workers.

As demand slackens in this labor market, the fate of this pool of skilled labor becomes uncertain. Under the terms of the visa program, the H-1B visa is specific to the employer. An H-1B visa holder who is laid off has a limited time to either locate a new employer and obtain approval for a new visa or the return to his/her home country. The immigrant is not allowed to work during this time period. These rules have two potential implications for labor force dynamics. One, a slackening in demand for workers in the science and technology sector may not show up as an increase in unemployment rates. Two, a temporary decrease in demand (2-4 months) could lead to a contraction of longer term supply (6-12 months) through the repatriation of this skilled workforce.

4.2 FIRM PROVIDED WORKER TRAINING

Another potential indicator of the slow response of supply to changes in demand is the willingness of employers to subsidize worker training. Economic theory predicts that in a competitive labor market employers will invest in firm-specific, but not general human capital. General human capital is portable. It enhances a worker's productivity at his current job and in any future job. Because of competition among employers, the benefits of an investment in general human capital tend to accrue to the worker. In contrast, an investment in firm specific human capital increases a worker's productivity at his current employer, but loses its value when the worker changes jobs. In this case, much of the benefit of training accrues to the employer rather than to the worker. Hence, in perfectly competitive labor markets, one would expect employers to pay for worker training that develops firm-specific skills and workers to pay for training that develops general skills.

Yet, many science and technology employers appear to be willing to invest in training that develop skills that are portable across employers. Lee and Walshok (2001) report that two-thirds of the students in the University of California at San Diego's extension courses received an employer subsidy and over half received 100% financing. In contrast, at the Riverside campus, a relatively low-tech region, half of the students received no subsidy from an employer.

One possible explanation of this phenomenon is that labor markets are imperfectly competitive. In an imperfectly competitive labor market, the employer may be able to capture some of the return to investment in general human capital and thus will have greater incentive to help pay for it. For example, there may be imperfect information about worker quality. If a current employer has better information about worker quality than a potential employer, a worker will be less able to move between employers and there will be less competition to bid up wages. The information asymmetry creates a wedge between a worker's salary and his productivity. This explanation seems an unlikely one for the science and technology sector because of the high turnover rates of workers.

Another explanation for the subsidy to general skills training is that it is a form of worker compensation. In the absence of the subsidy, the firm would pay the worker a higher wage. This arrangement makes economic sense for the employer if the amount spent on training is less than what the employer would have had to offer as additional salary. It makes sense for the worker if the value of the training subsidy exceeds what the worker would have received as additional salary. The arithmetic works only if the employer can provide training at a lower cost than the worker could obtain on his own. This seems likely in the science and technology sector because the pace of technological change increases the risk associated with investment in learning any one skill and the employer may be better positioned to diversify that risk. As the pace of technological change slows, workers may increasingly be required to finance their own training.[11]

Because employers subsidize training, the availability of training affects the demand for workers as well as the supply. If low cost, high quality training is readily available, it lowers a firm's cost of hiring a worker and increases demand. Large firms may provide this training directly, but for small and medium sized firms the cost per worker of in-house training may be prohibitive. (ASTD) The prevalence of small to medium sized firms in California's science and technology sector increases the demand for third party training providers. Lee and Walshok (2001) have begun the task of documenting the importance of public educational institutions in providing this training. More information is needed about the role of the nonprofit and proprietary sectors.[12]

11 If a firm does not finance a worker's investment in training, the worker has other options. Several private companies, including Microsoft, offer lending programs. A Career Training Loan is available under the aegis of Sallie Mae. The federal tax code offers a tax credit to workers engaged in skill upgrading and taxpayers may withdraw funds from an IRA without penalty to finance post-secondary educational expenses. Finally, displaced workers may be eligible for funding under the Workforce Investment Act.

12 According to the U.S. Economic Census there were 347 proprietary computer training schools in California in 1997. Appendix Table A-3 describes the results of a search of a large online database of computer training providers (www.computertrainingschools.com) The database lists 189 computer training providers in the state. A majority of the courses listed were offered by the proprietary schools.

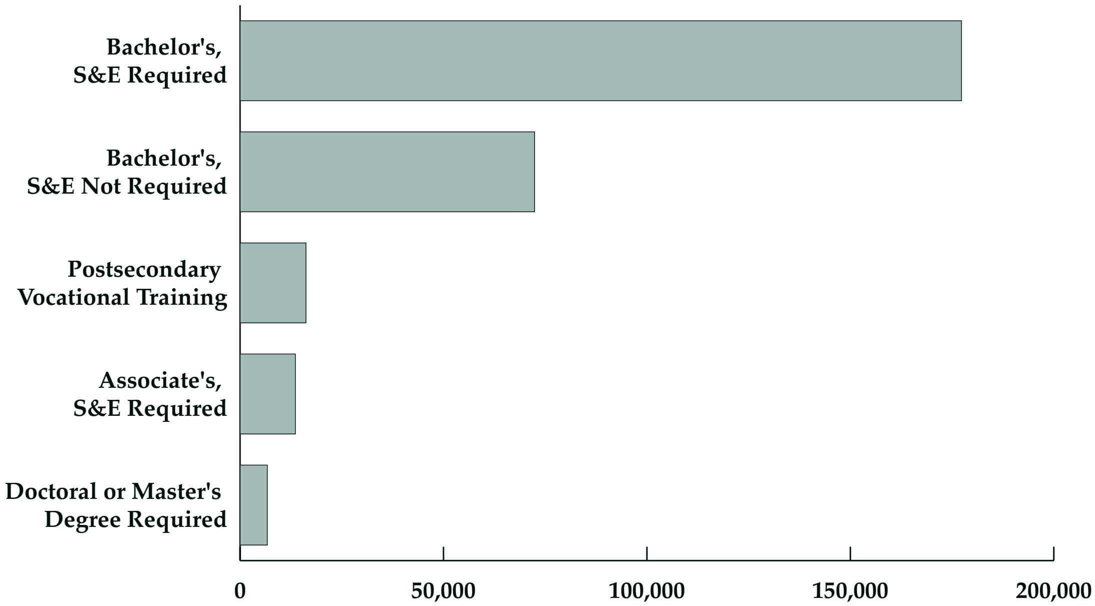


Figure 4.1 -- Projected Employment Growth by Educational Attainment, 1998-2008

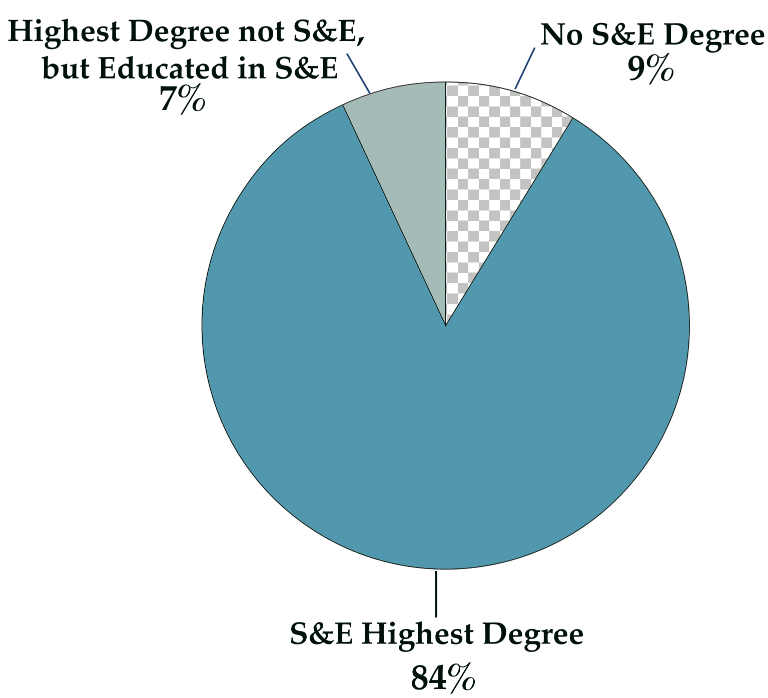


Figure 4.2 - Distribution of U.S. Scientists and Engineers by Degree Type

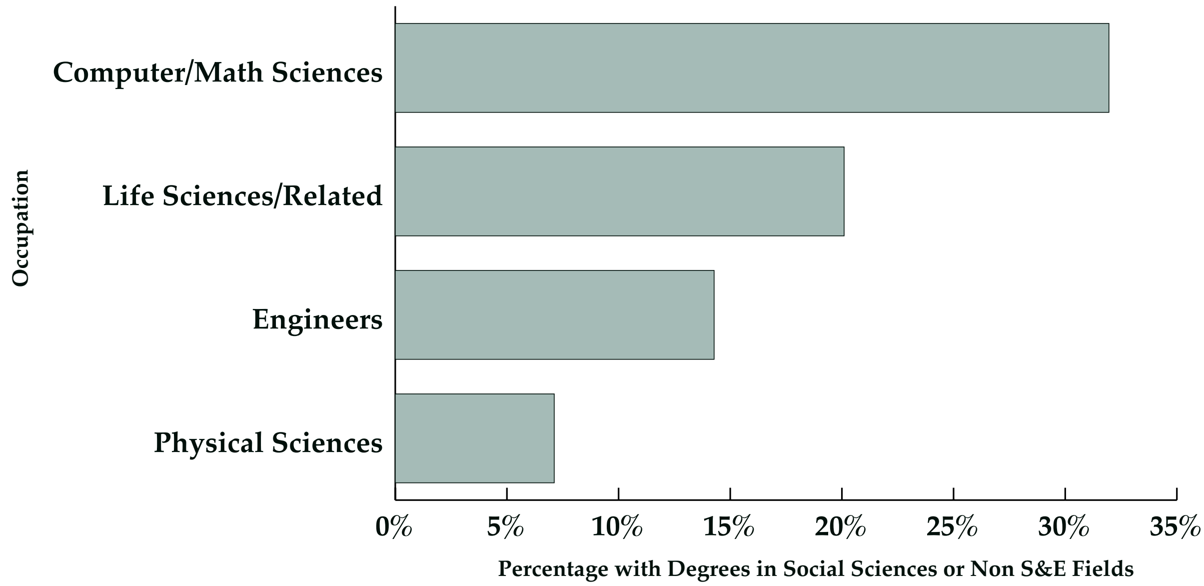
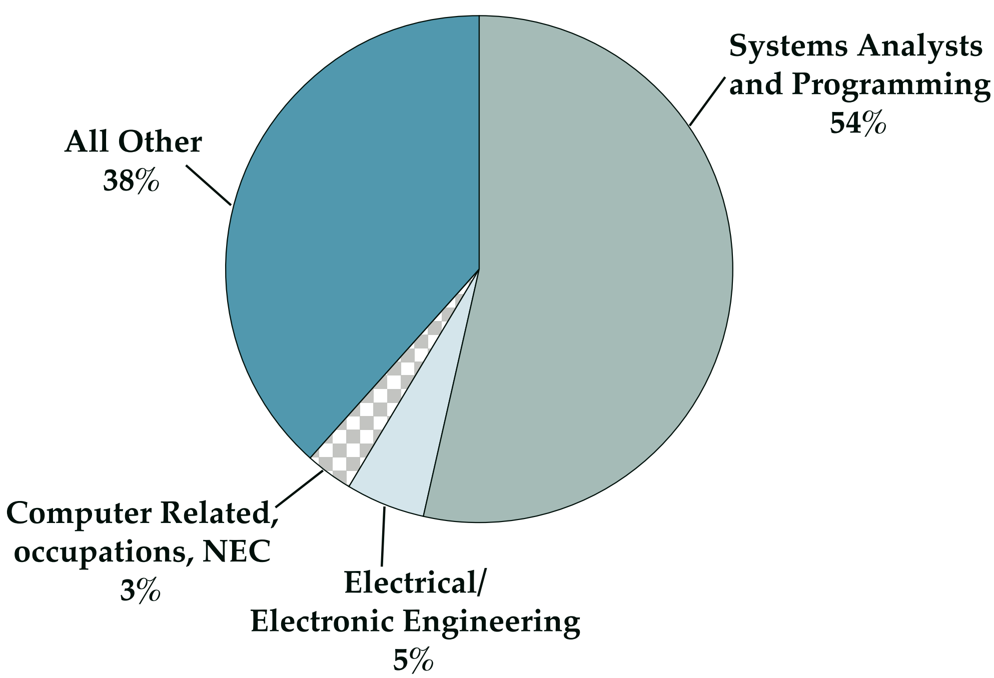


Figure 4.3 -- Percentage of U.S. Scientists and Engineers with Degrees Outside of Science and Engineering by Occupation



Source: U.S. Immigration and Naturalization Service, "Characteristics of Specialty Occupation Workers (H-1B) May 1998-July 1999," February 2000, http://www.ins.gov/graphics/services/employerinfo/report1.pdf.
Figure 4.4 -- Distribution of H-1B Visa Approvals by Occupation, 2000

Table 4.1
Skill Demand in California's Science and Technology Industries, 1998

INDUSTRY	TOTAL EMPLOYED					PERCENT OF TOTAL			
	All Occupations	Doctoral or Master's Degree Required	Bachelor's in S&E Required	Associate's in S&E Required	Bachelor's , Not S&E Required	Doctoral or Master's Degree Required	Bachelor's in S&E Required	Associate's in S&E Required	Bachelor's , Not S&E Required
Drugs	33,000	2,400	3,000	2,000	3,500	7.3%	9.1%	6.1%	10.6%
Computer & Office Equipment	95,400	100	30,400	4,000	9,400	0.1%	31.9%	4.2%	9.9%
Communications Equip	39,200	0	6,900	1,700	5,900	0.0%	17.6%	4.3%	15.1%
Computer & Data Processing Services	243,000	2,200	117,200	4,800	48,400	0.9%	48.2%	2.0%	19.9%
Search & Navigation Equipment	57,200	100	22,900	4,100	11,600	0.2%	40.0%	7.2%	20.3%
Measuring & Control Devices	68,500	100	16,100	4,800	9,100	0.1%	23.5%	7.0%	13.3%
Other Instruments	56,700	300	5,400	2,500	7,500	0.5%	9.5%	4.4%	13.2%
Communications	169,700	100	11,300	4,700	25,400	0.1%	6.7%	2.8%	15.0%
Aircraft & Parts	89,400	0	15,600	5,900	13,200	0.0%	17.4%	6.6%	14.8%
Guided Missiles	24,900	400	10,500	1,000	2,900	1.6%	42.2%	4.0%	11.6%
Engineering & Management	434,000	11,800	85,400	28,400	137,710	2.7%	19.7%	6.5%	31.7%
Electronic Components	158,900	0	31,300	9,600	18,500	0.0%	19.7%	6.0%	11.6%
Total S&T	1,580,100	17,500	356,000	73,500	293,110	1.1%	22.5%	4.7%	18.6%

Source: California Industry and Occupation Staffing Patterns, www.calmis.ca.gov, retrieved May 2001.

Table 4.2
Projected Employment Growth in California's Science and Technology Industries, 1998-2008 by Educational Requirement

INDUSTRY	Projected Growth in Employment 1998-2008					Projected Growth in Employment in Percent				
	Doctoral or Master's Degree Required	Bachelor's in S&E Required	Associate's in S&E Required	Postsecondary Vocational Training	Bachelor's , Not S&E Required	Doctoral or Master's Degree Required	Bachelor's in S&E Required	Associate's in S&E Required	Postsecondary Vocational Training	Bachelor's, S&E Not Required
Drugs	1,100	900	200	0	600	46%	30%	10%	-	17%
Computer & Office Equipment	0	6,700	300	-100	600	0%	22%	8%	-14%	6%
Communications Equip	0	1,800	200	300	1,200	-	26%	12%	20%	20%
Computer & Data Processing Services	300	103,900	600	1,000	23,000	14%	89%	13%	18%	48%
Search & Navigation Equipment	0	5,000	400	0	600	0%	22%	10%	0%	5%
Measuring & Control Devices	100	4,500	600	0	1,600	100%	28%	13%	-	18%
Other Instruments	100	1,900	800	0	1,200	33%	35%	32%	0%	16%
Communications	0	3,600	-1,200	-400	-8,900	0%	32%	-26%	-5%	-35%
Aircraft & Parts	0	2,100	800	100	1,800	-	13%	14%	3%	14%
Guided Missiles	-100	2,300	100	0	200	-25%	22%	10%	0%	7%
Eng & Mgt	5,200	36,100	8,700	15,300	47,390	44%	42%	31%	36%	34%
Electronic Comp.	0	8,500	2,100	0	3,100	-	27%	22%	0%	17%
Total S&T	6,700	177,300	13,600	16,200	72,390	38%	50%	19%	25%	25%

Source: California Industry and Occupation Staffing Patterns, www.calmis.ca.gov, retrieved May 2001.

Table 4.3
Characteristics of H-1B Visa Survey Respondents

Number of respondents		**27**
Demographics		
Proportion Male		**96%**
Proportion from India		**74%**
Highest Degree Earned	**Bachelors**	**37%**
	Masters	**52%**
	Advanced	**11%**
Occupational Distribution		
Software Engineer		**10**
Database Administrator		**5**
Programmer		**4**
Other		**8**
Frequency of Reported Computer Software/System Knowledge		
Oracle		**16**
MS-SQL		**14**
C/C++		**12**
Visual Basic		**10**
JAVA		**8**
ASP		**5**
VC++		**4**
Cobol		**3**
Perl		**2**
DBI		**2**

Table 4.4
Californians Employed in S&T Occupations by Immigrant Status, March 2001

Demographic Characteristics							
	U.S. Born Citizens	**Naturalized Citizens**	**Not a Citizen**	**Not A Citizen, Arrival Since 1994**			
Age	**38.9**	**39.4**	**33.6**	**30.7**			
% Female	**23.8**	**22.6**	**29.8**	**31.0**			
% with Masters	**10.0**	**22.6**	**31.9**	**27.6**			
% with Ph.D.	**5.6**	**1.9**	**8.5**	**10.3**			
Occupatonal Distribution							
Occupation	**U.S. Born Citizens**	**Naturalized Citizens**	**Not a Citizen**	**Not A Citizen, Arrival Since 1994**	**Total Employed**	**% Possibly H-1B**	**% Noncitizen**
Engineer	**61**	**20**	**16**	**9**	**97**	**9.28%**	**16.49%**
Computer/Math Scientist	**62**	**18**	**22**	**15**	**102**	**14.71%**	**21.57%**
Natural Scientist	**11**	**1**	**3**	**2**	**15**	**13.33%**	**20.00%**
Engineering & Science Technicians	**22**	**13**	**5**	**2**	**40**	**5.00%**	**12.50%**
Distribution by Industry							
Industry							
Computer Manufacturing	**3**	**3**	**8**	**4**	**14**	**28.57%**	**57.14%**
Electrical Equipment & Components	**6**	**5**	**7**	**5**	**18**	**27.78%**	**38.89%**
Computer Programming Services	**33**	**10**	**13**	**12**	**56**	**21.43%**	**23.21%**
Other S&T	**42**	**9**	**7**	**3**	**58**	**5.17%**	**12.07%**
Outside of S&T	**76**	**26**	**12**	**5**	**114**	**4.39%**	**10.53%**

Source: U.S. Current Population Survey, March 2001, http:www.census.gov, retrieved June 2001.

5. DEMOGRAPHICS OF SCIENCE AND TECHNOLOGY LABOR MARKET

By several indicators, African American, Latinos and women of all races are underrepresented in the science and technology workforce. The open question is whether this reflects employer demand or limitations of supply. In either case, it suggests a constraint on the ability of workers to compete for jobs. A constraint on a worker's ability to compete for jobs, such as a lack of educational opportunity or employer prejudice, not only slows the adjustment to market equilibrium, but can lead to wages that are artificially high.

On the supply side, African Americans and Latinos have lower rates of college completion than white or Asian American men. White women have similar rates of college completion, but women, as a group, are less likely to major in science and engineering fields other than social science. On the demand side, employers may have different perceptions of the skills of these groups either because of lack of information or prejudice or these workers may not be part of employers' recruitment networks. These demand side obstacles may lead to lower earnings or higher rates of unemployment, holding skills constant, and in the longer term reduce the flow of minority and women workers into the industry.

To examine the demographic composition of the science and technology workforce, we turn to three different sources of data. Each has significant limitations. The traditional source of data used to benchmark employer progress toward affirmative action goals in local labor markets is the decennial census of the population. Unfortunately, data on the occupational distribution of the population by race, ethnicity and gender is not yet available for the 2000 Census. Table 5.1 reports the breakdown of selected science and engineering occupations by race and gender for 1990. Blacks and Latinos are underrepresented in science and engineering occupations relative to their proportion of the total workforce and relative to their proportion of the workforce with college degrees, but there are exceptions. Blacks and Latinos are over-represented among biological technicians. Blacks are over-represented among mathematical scientists.

More recent data on employment in science and engineering occupations is available from the National Science Foundation's SESTAT database. This database uses the term "scientist and engineers" to include all individuals who have ever received a bachelor's degree in a science or engineering field, plus persons holding non-science and engineering bachelor's or higher degree who were employed in a science or engineering occupation. Table 5.2 reports the distribution of science and engineers by race and occupation for the United States. African Americans represent 3.4% of all scientists and engineers (including social and related sciences); Hispanics, 3.1%. African Americans make up 12% of the civilian labor force and Hispanics, 10.7%. Asian Americans, according to NSF data, constitute 10.4% of U.S. scientists and engineers although they are only 4% of the population. Women of any race represent 22.8% of science and engineers.

The NSF data also has information on employment status. Table 5.3 reports the employment status of workers by race and gender. Unemployment rates are higher for white women, blacks, Latinos and Asian Americans than for white men. These differences in unemployment rates are not readily attributable to differences in skill.

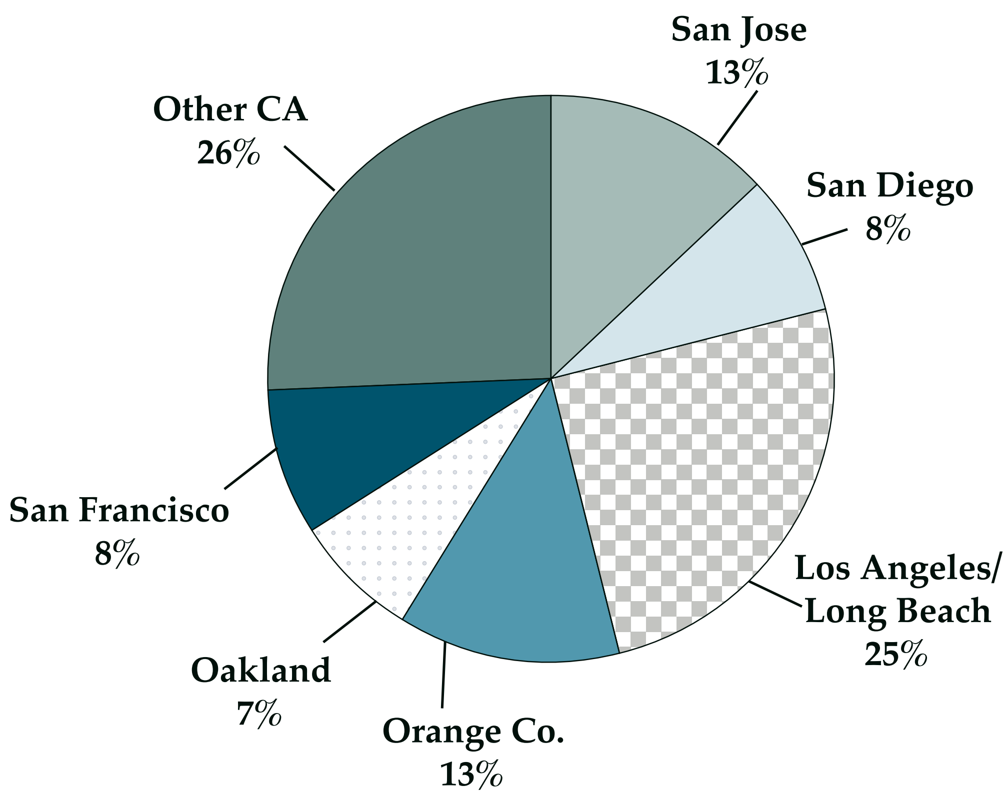
Table 5.4 reports demographic data from a third source, the Equal Employment Opportunity Commission (EEOC).[13] The EEOC data offers a different snapshot of workforce

13 Private employers with 100 or more employees or employers with 50 or more employees who are federal contractors must file periodic reports with the EEOC.

diversity. It gives a breakdown by industry, but uses broad occupational categories. According the EEOC data, African Americans represent 5.2% of professional workers in S&T compared with 7.4% of professional workers in all industries. In contrast, Hispanics represent a similar percentage of professional workers in S&T as they do in other industries. Black and Hispanic men have a higher share of technical (i.e., electrical engineering technicians; biological technicians) jobs in S&T than they do in other industries; but black and Hispanic women are under-represented in this category as are white and Asian American women.

These data alone do not allow us to distinguish whether racial and gender differences are due to demand or supply. However, the under-representation of these groups in the science and technology workforce points to a potentially under developed or under utilized pool of labor for this industry.

Yet the demands of family and the travel time to and from work pose constraints on a worker's ability to invest in both formal and informal training. In a survey conducted under the auspices of the San Diego Workforce Partnership, a lack of time was the major training issue cited by information technology workers.



Source: 1997 Economic Census.
Figure 5.1 --Proprietary Computer Training Schools in California, 1997.

Table 5.1
Racial Composition of Science and Engineering Occupations in California, 1990 Census

California Occupation	Proportion, Black, Non Hispanic	Proportion Hispanic, Any Race	Proportion Asian & Pacific Islander	Proportion American Indian
All Engineers				
Aeronautical & Aerospace Engineers	4.01%	5.97%	13.70%	0.47%
Biological & Life Scientists	1.26%	6.42%	13.68%	0.35%
Computer Programmers	4.12%	5.79%	19.19%	0.23%
Mathematical Scientists	6.73%	2.83%	10.81%	0.00%
Electrical & Electronic Engineers	3.07%	5.26%	20.33%	0.43%
Computer Scientists	3.66%	4.82%	17.95%	0.36%
Biological Technicians	2.65%	29.33%	13.80%	0.53%
Total Workforce	6.06%	22.68%	9.46%	0.76%

Source: U.S. Census of the Population 1990, EE0-1 Files.

Table 5.2
Distribution of Science and Engineers by Occupation, Race and Gender, NSF Data, 1997

	Total Women	Total Men	White Women	White Men	API Women	API Men	Black Women	Black Men	Hispanic Women	Hispanic Men	Amerind Women	Amerind Men
Total S&E	780,300	2,641,900	624,000	2,208,200	83,800	273,100	41,700	73,600	27,600	78,600	2,800	7,300
Computer/Math Scientists	287,500	766,600	222,800	627,700	37,800	90,700	17,800	27,600	8,200	18,700	600	1,200
Post Secondary Teachers	24,900	47,400	20,100	39,000	1,900	5,600	1,800	1,300	1,000	1,300	100	100
Computer/Math Scientists, Excluding Post Secondary Teachers	262,600	719,200	202,700	588,700	35,900	85,100	16,000	26,300	7,200	17,400	500	1,100
Life & Related	119,200	209,900	97,400	180,200	14,500	19,100	3,400	4,800	3,600	4,800	400	1,000
Post Secondary Teachers	26,500	51,600	23,000	46,000	1,600	3,500	900	900	900	1,100	0	100
Life & Related, Excluding Post Secondary Teachers	92,700	158,300	74,400	134,200	12,900	15,600	2,500	3,900	2,700	3,700	400	900
Physical Sciences	63,400	226,000	48,500	195,000	8,900	19,500	3,300	5,200	2,400	5,500	200	800
Post Secondary Teachers	10,800	37,800	8,500	33,100	1,300	2,600	300	800	600	900	100	200
Physical Sciences, Excluding Post Secondary Teachers	52,600	188,200	40,000	161,900	7,600	16,900	3,000	4,400	1,800	4,600	100	600
Engineers	126,800	1,270,300	97,200	1,057,800	16,400	136,500	7,800	28,500	4,900	43,600	400	3,500
Post Secondary Teachers	3,200	31,100	2,600	23,400	400	5,400	100	1,000	100	1,100	0	0
Engineers Less Post Secondary Teachers	123,600	1,239,200	94,600	1,034,400	16,000	131,100	7,700	27,500	4,800	42,500	400	3,500
Social & Related Scientists	183,500	169,000	158,100	147,500	6,100	7,200	9,400	7,500	8,600	5,900	1,200	800
Post Secondary Teachers	32,300	53,600	26,400	45,900	1,700	3,600	2,400	1,900	1,600	1,900	200	300
Social Scientists, Excluding Post Secondary Teachers	151,200	115,400	131,700	101,600	4,400	3,600	7,000	5,600	7,000	4,000	1,000	500
Total S&E Less Social Scientists	596,800	2,472,900	465,900	2,060,700	77,700	265,900	32,300	66,100	19,000	72,700	1,600	6,500
Total S&E Less Social Sciences & Post Secondary Teachers	531,400	2,305,000	411,700	1,919,200	72,500	248,800	29,200	62,100	16,400	68,300	1,400	6,100

Source: National Science Foundation, *Women, Minorities and Persons with Disabilities in Science and Engineering 2000,* www.nsf.gov/sbe/svs/nsf00327/start.htm, Appendix Table 5-3.

Table 5.2((continued)
Distribution of Science and Engineers by Occupation, Race and Gender, NSF Data, 1997

Percent Distribution	Total Women	Total Men	White Women	White Men	API Women	API Men	Black Women	Black Men	Hispanic Women	Hispanic Men	Amerind Women	Amerind Men
Total S&E	22.8%	77.2%	18.2%	64.5%	2.4%	8.0%	1.2%	2.2%	0.8%	2.3%	0.1%	0.2%
Computer/Math Scientists	27.3%	72.7%	21.1%	59.5%	3.6%	8.6%	1.7%	2.6%	0.8%	1.8%	0.1%	0.1%
Post Secondary Teachers	34.4%	65.6%	27.8%	53.9%	2.6%	7.7%	2.5%	1.8%	1.4%	1.8%	0.1%	0.1%
Computer/Math Scientists, Excluding Post Secondary Teachers	26.7%	73.3%	20.6%	60.0%	3.7%	8.7%	1.6%	2.7%	0.7%	1.8%	0.1%	0.1%
Life & Related	36.2%	63.8%	29.6%	54.8%	4.4%	5.8%	1.0%	1.5%	1.1%	1.5%	0.1%	0.3%
Post Secondary Teachers	33.9%	66.1%	29.4%	58.9%	2.0%	4.5%	1.2%	1.2%	1.2%	1.4%	0.0%	0.1%
Life & Related, Excluding Post Secondary Teachers	36.9%	63.1%	29.6%	53.5%	5.1%	6.2%	1.0%	1.6%	1.1%	1.5%	0.2%	0.4%
Physical Sciences	21.9%	78.1%	16.8%	67.4%	3.1%	6.7%	1.1%	1.8%	0.8%	1.9%	0.1%	0.3%
Post Secondary Teachers	22.2%	77.8%	17.5%	68.1%	2.7%	5.3%	0.6%	1.6%	1.2%	1.9%	0.2%	0.4%
Physical Sciences, Excluding Post Secondary Teachers	21.8%	78.2%	16.6%	67.2%	3.2%	7.0%	1.2%	1.8%	0.7%	1.9%	0.0%	0.2%
Engineers	9.1%	90.9%	7.0%	75.7%	1.2%	9.8%	0.6%	2.0%	0.4%	3.1%	0.0%	0.3%
Post Secondary Teachers	9.3%	90.7%	7.6%	68.2%	1.2%	15.7%	0.3%	2.9%	0.3%	3.2%	0.0%	0.0%
Engineers Less Post Secondary Teachers	9.1%	90.9%	6.9%	75.9%	1.2%	9.6%	0.6%	2.0%	0.4%	3.1%	0.0%	0.3%
Social & Related Scientists	52.1%	47.9%	44.9%	41.8%	1.7%	2.0%	2.7%	2.1%	2.4%	1.7%	0.3%	0.2%
Post Secondary Teachers	37.6%	62.4%	30.7%	53.4%	2.0%	4.2%	2.8%	2.2%	1.9%	2.2%	0.2%	0.3%
Social Scientists, Excluding Post Secondary Teachers	56.7%	43.3%	49.4%	38.1%	1.7%	1.4%	2.6%	2.1%	2.6%	1.5%	0.4%	0.2%
Total S&E Less Social Scientists	19.4%	80.6%	15.2%	67.1%	2.5%	8.7%	1.1%	2.2%	0.6%	2.4%	0.1%	0.2%
Total S&E Less Social Sciences & Post Secondary Teachers	18.7%	81.3%	14.5%	67.7%	2.6%	8.8%	1.0%	2.2%	0.6%	2.4%	0.0%	0.2%

Source: National Science Foundation, *Women, Minorities and Persons with Disabilities in Science and Engineering 2000,* www.nsf.gov/sbe/svs/nsf00327/start.htm, Appendix Table 5-3.

Table 5.3
Employment Status of U.S. Scientists and Engineers by Race and Sex

	Total	Employed, Full Time or Postdoc	Employed Part Time	Unemployed	Out of Labor Force	Unemployment Rate	Part Timer Rate
White Men	**2,534,500**	**2,062,200**	**118,100**	**27,800**	**326,400**	**0.01**	**0.05**
White Women	**725,500**	**499,800**	**111,500**	**12,700**	**101,500**	**0.02**	**0.15**
Black Men	**79,400**	**68,600**	**3,700**	**1,300**	**5,900**	**0.02**	**0.05**
Black Women	**47,100**	**36,800**	**3,800**	**1,000**	**5,500**	**0.02**	**0.08**
Hispanic Men	**84,300**	**73,000**	**3,800**	**1,900**	**5,700**	**0.02**	**0.05**
Hispanic Women	**30,600**	**22,300**	**4,400**	**900**	**2,900**	**0.03**	**0.14**
API Men	**293,300**	**257,400**	**10,800**	**4,800**	**20,100**	**0.02**	**0.04**
API Women	**91,400**	**77,000**	**6,600**	**2,300**	**7,700**	**0.03**	**0.07**
Amerind Men	**7,700**	**6,700**	**400**	**100**	**500**	**0.01**	**0.05**
Amerind Women	**2,900**	**2,400**	**300**	**0**	**100**	**0.00**	**0.10**

Source: National Science Foundation, *Women, Minorities and Persons with Disabilities in Science and Engineering 2000*, www.nsf.gov/sbe/svs/nsf00327/start.htm, Appendix Table 5-8.

Table 5.4, Part A

Demographic Composition of Science and Technology Industries, EEOC Data 1999

Part A: Professional Workers INDUSTRY	SIC	# Units Filing Reports	Total Employed	White Men	White Women	Black Men	Black Women	Hispanic Men	Hispanic Women	Asian American Men	Asian American Women
Measuring & Control Devices	382	986	66,784	42,256	12,650	1,381	828	1,650	604	5,172	1,987
Search & Navigation	381	160	28,643	20,117	4,807	689	336	638	233	1,332	413
Guided Missiles	376	83	39,125	25,479	6,481	852	514	1,322	526	2,827	878
Communications Equipment	366	712	98,383	57,541	17,417	2,865	1,677	2,965	1,190	10,565	3,802
Aircraft & Parts	372	683	116,658	79,976	20,296	2,796	1,733	2,926	1,085	5,703	1,638
Electronic Components	367	1,514	131,714	71,765	21,809	2,669	1,567	5,665	2,067	7,723	2,858
Computer & Office Equipment	357	858	134,811	76,603	29,458	3,487	2,828	2,328	481	3,331	837
Drugs	283	584	86,463	34,536	32,288	1,840	2,468	1,424	1,447	6,226	6,049
Medical Instruments & Supplies	384	738	44,466	23,946	13,006	795	645	1,247	773	2,563	1,384
Telephone Communication	481	3,815	152,440	70,765	44,187	6,780	8,465	3,537	2,592	10,017	5,252
Computer & Data Processing Services	737	4,143	457,470	228,510	123,104	14,038	13,990	8,718	5,066	44,330	17,807
Engineering & Architectural Services	871	2,216	165,524	108,382	29,904	4,578	2,601	3,916	1,411	10,968	3,178
Research & Testing	873	980	116,879	59,282	34,782	2,115	2,782	2,485	1,817	8,233	4,942
Total S&T		17,472	1,639,360	899,158	390,189	44,885	40,434	38,821	19,292	118,990	51,025
All Industries, U.S.		193,284	6,785,176	2,751,893	2,796,254	159,235	291,144	118,510	118,949	279,033	243,834
All Industries, California		20,368	766,257	273,362	228,146	14,719	21,239	27,607	27,991	86,772	82,705
IN PERCENT											
Measuring & Control Devices			100.00%	63.27%	18.94%	2.07%	1.24%	2.47%	0.90%	7.74%	2.98%
Search & Navigation			100.00%	70.23%	16.78%	2.41%	1.17%	2.23%	0.81%	4.65%	1.44%
Guided Missiles			100.00%	65.12%	16.56%	2.18%	1.31%	3.38%	1.34%	7.23%	2.24%
Communications Equipment			100.00%	58.49%	17.70%	2.91%	1.70%	3.01%	1.21%	10.74%	3.86%
Aircraft & Parts			100.00%	68.56%	17.40%	2.40%	1.49%	2.51%	0.93%	4.89%	1.40%
Electronic Components			100.00%	54.49%	16.56%	2.03%	1.19%	4.30%	1.57%	5.86%	2.17%
Computer & Office Equipment			100.00%	56.82%	21.85%	2.59%	2.10%	1.73%	0.36%	2.47%	0.62%
Drugs			100.00%	39.94%	37.34%	2.13%	2.85%	1.65%	1.67%	7.20%	7.00%
Medical Instruments & Supplies			100.00%	53.85%	29.25%	1.79%	1.45%	2.80%	1.74%	5.76%	3.11%
Telephone Communication			100.00%	46.42%	28.99%	4.45%	5.55%	2.32%	1.70%	6.57%	3.45%
Computer & Data Processing Services			100.00%	49.95%	26.91%	3.07%	3.06%	1.91%	1.11%	9.69%	3.89%
Engineering & Architectural Services			100.00%	65.48%	18.07%	2.77%	1.57%	2.37%	0.85%	6.63%	1.92%
Research & Testing			100.00%	50.72%	29.76%	1.81%	2.38%	2.13%	1.55%	7.04%	4.23%
Total S&T			100.00%	54.85%	23.80%	2.74%	2.47%	2.37%	1.18%	7.26%	3.11%
All Industries, U.S.			100.00%	40.56%	41.21%	2.35%	4.29%	1.75%	1.75%	4.11%	3.59%
All Industries, California			100.00%	35.67%	29.77%	1.92%	2.77%	3.60%	3.65%	11.32%	10.79%

Source: EEOC Data, *Job Patterns for Minorities and Women in Private Industry*, 1999.

Table 5.4, Part B

Demographic Composition of Science and Technology Industries, EEOC Data 1999

Part B: Technical Workers INDUSTRY	SIC	# Units Filing Reports	Total Employed	White Men	White Women	Black Men	Black Women	Hispanic Men	Hispanic Women	Asian American Men	Asian American Women
Measuring & Control Devices	382	986	30,571	20,715	3,531	1,234	428	1,557	331	2,007	602
Search & Navigation	381	160	7,521	4,967	1,061	325	116	371	88	450	106
Guided Missiles	376	83	6,216	4,059	931	247	92	353	165	240	72
Communications Equipment	366	712	31,724	19,786	3,438	2,265	532	1,839	380	2,675	635
Aircraft & Parts	372	683	30,625	20,287	5,068	1,159	460	1,425	313	1,352	335
Electronic Components	367	1,514	66,610	34,724	8,803	3,138	1,128	5,665	2,067	7,723	2,858
Computer & Office Equipment	357	858	43,169	28,420	4,471	2,413	663	2,328	481	3,331	837
Drugs	283	584	21,785	8,763	7,168	1,023	1,241	869	557	1,048	1,007
Medical Instruments & Supplies	384	738	19,468	10,216	3,713	806	460	1,272	519	1,586	808
Telephone Communication	481	3,815	66,200	40,504	11,136	4,954	2,988	2,667	793	1,853	871
Computer & Data Processing Services	737	4,143	122,350	67,561	24,115	7,980	4,455	4,725	1,788	8,054	2,821
Engineering & Architectural Services	871	2,216	62,598	41,648	9,661	3,294	1,008	2,979	617	2,257	705
Research & Testing	873	980	39,851	19,416	10,541	1,563	1,275	2,342	1,022	1,865	1,552
Total S&T		17,472	548,688	321,066	93,637	30,401	14,846	28,392	9,121	34,441	13,209
All Industries, U.S.			2,626,624	1,119,701	885,584	122,848	175,884	64,986	143,499	84,423	59,076
IN PERCENT											
Measuring & Control Devices			100.00%	67.76%	11.55%	4.04%	1.40%	5.09%	1.08%	6.57%	1.97%
Search & Navigation			100.00%	66.04%	14.11%	4.32%	1.54%	4.93%	1.17%	5.98%	1.41%
Guided Missiles			100.00%	65.30%	14.98%	3.97%	1.48%	5.68%	2.65%	3.86%	1.16%
Communications Equipment			100.00%	62.37%	10.84%	7.14%	1.68%	5.80%	1.20%	8.43%	2.00%
Aircraft & Parts			100.00%	66.24%	16.55%	3.78%	1.50%	4.65%	1.02%	4.41%	1.09%
Electronic Components			100.00%	52.13%	13.22%	4.71%	1.69%	8.50%	3.10%	11.59%	4.29%
Computer & Office Equipment			100.00%	65.83%	10.36%	5.59%	1.54%	5.39%	1.11%	7.72%	1.94%
Drugs			100.00%	40.22%	32.90%	4.70%	5.70%	3.99%	2.56%	4.81%	4.62%
Medical Instruments & Supplies			100.00%	52.48%	19.07%	4.14%	2.36%	6.53%	2.67%	8.15%	4.15%
Telephone Communication			100.00%	61.18%	16.82%	7.48%	4.51%	4.03%	1.20%	2.80%	1.32%
Computer & Data Processing Services			100.00%	55.22%	19.71%	6.52%	3.64%	3.86%	1.46%	6.58%	2.31%
Engineering & Architectural Services			100.00%	66.53%	15.43%	5.26%	1.61%	4.76%	0.99%	3.61%	1.13%
Research & Testing			100.00%	48.72%	26.45%	3.92%	3.20%	5.88%	2.56%	4.68%	3.89%
Total S&T			100.00%	58.52%	17.07%	5.54%	2.71%	5.17%	1.66%	6.28%	2.41%
All Industries, U.S.			100.00%	42.63%	33.72%	4.68%	6.70%	2.47%	5.46%	3.21%	2.25%

Source: EEOC Data, *Job Patterns for Minorities and Women in Private Industry*, 1999.

6. LESSONS FOR THE CRITICAL PATH ANALYSIS

Most of the employment growth in California's science and technology sector will come from jobs that require a bachelor's degree or higher in a science or engineering field. Even jobs with lower degree requirements demand an understanding of mathematics and the scientific method. For a worker with those skills, the science and technology sector offers employment at high wages. A worker without these basic skills will find his or her employment prospects in this sector extremely limited.

The popularity of H-1B visa programs and the existence of employer subsidies for training suggest a slow response of labor supply to changes in demand. The H-1B visa program appears to function as a shock absorber -- allowing a quick expansion of labor supply in response to an increase in demand. However, public policy must address what happens to H-1B visa workers during periods of slack demand. In addition, there is too little data to analyze the impact of the H-1B visa program on local labor markets.

This study has found little evidence of demand side obstacles to the market adjustment process, but there is one issue requiring further study. Why do minority and women scientists have higher rates of unemployment? One possibility is the existence of an inefficiency in the recruitment and screening process that might limit the full utilization of the pool of skilled labor. Another possibility is that there are differences in skill that reflect differential access to training. If there is differential access to training, the market is not functioning efficiently.

Table A-1
Science and Technology Employment, Selected States, 1997

NUMBER OF PAID EMPLOYEES, 1997	U.S. Total	CA	CT	IL	MA	NJ	NY	TX	WA
Aerospace	488,055	102,956	35,351	5,685	5,972	2,166	8,677	41,973	D
Computers & Electronic Products	1,698,529	396,482	24,195	76,625	105,506	39,058	86,243	135,625	46,235
Software Publishers	266,380	77,277	3,210	13,176	29,670	8,199	11,249	16,018	10,464
Online Information Services	49,935	9,822	551	1,311	2,738	910	6,401	2,378	1,607
Data Processing Services	262,250	20,679	6,882	7,959	10,322	7,137	23,011	27,088	1,982
Computer Systems Design	764,659	101,494	9,377	41,999	32,595	50,602	41,878	50,071	13,232
Scientific R&D in Physical, Engineering & Life Sciences (Taxable Only)	161,304	37,347	892	2,110	8,571	7,750	6,413	7,096	5,857
Telecommunications	1,010,389	116,253	960	43,107	26,502	1,247	77,420	84,676	5,928
Pharmaceuticals	203,026	27,022	9,338	19,391	7,102	23,881	18,825	6,493	1,243
Basic Chemical Manufacturing	202,486	5,795	1,036	7,286	1,350	9,995	5,995	35,142	1,898
Testing Laboratories	82,024	11,981	1,264	4,318	1,828	2,681	4,566	8,394	1,594
Total S&T	5,189,037	907,108	90,756	211,363	228,978	140,950	280,117	371,418	86,548
All Sectors	66,751,363	10,153,844	1,239,036	4,295,644	2,317,067	2,811,684	5,506,981	6,324,854	1,756,780
PERCENTAGE SHARE OF U.S. TOTAL									
Aerospace	100.0%	21.1%	7.2%	1.2%	1.2%	0.4%	1.8%	8.6%	NA
Computers & Electronic Products	100.0%	23.3%	1.4%	4.5%	6.2%	2.3%	5.1%	8.0%	2.7%
Software Publishers	100.0%	29.0%	1.2%	4.9%	11.1%	3.1%	4.2%	6.0%	3.9%
Online Information Services	100.0%	19.7%	1.1%	2.6%	5.5%	1.8%	12.8%	4.8%	3.2%
Data Processing Services	100.0%	7.9%	2.6%	3.0%	3.9%	2.7%	8.8%	10.3%	0.8%
Computer Systems Design	100.0%	13.3%	1.2%	5.5%	4.3%	6.6%	5.5%	6.5%	1.7%
Scientific R&D in Physical, Engineering & Life Sciences (Taxable Only)	100.0%	23.2%	0.6%	1.3%	5.3%	4.8%	4.0%	4.4%	3.6%
Telecommunications	100.0%	11.5%	0.1%	4.3%	2.6%	0.1%	7.7%	8.4%	0.6%
Pharmaceuticals	100.0%	13.3%	4.6%	9.6%	3.5%	11.8%	9.3%	3.2%	0.6%
Basic Chemical Manufacturing	100.0%	2.9%	0.5%	3.6%	0.7%	4.9%	3.0%	17.4%	0.9%
Testing Laboratories	100.0%	14.6%	1.5%	5.3%	2.2%	3.3%	5.6%	10.2%	1.9%
Total S&T	100.0%	17.5%	1.7%	4.1%	4.4%	2.7%	5.4%	7.2%	1.7%
All Sectors	100.0%	15.2%	1.9%	6.4%	3.5%	4.2%	8.2%	9.5%	2.6%
SHARE OF STATE EMPLOYMENT									
Aerospace	0.7%	1.0%	2.9%	0.1%	0.3%	0.1%	0.2%	0.7%	NA
Computers & Electronic Products	2.5%	3.9%	2.0%	1.8%	4.6%	1.4%	1.6%	2.1%	2.6%
Software Publishers	0.4%	0.8%	0.3%	0.3%	1.3%	0.3%	0.2%	0.3%	0.6%
Online Information Services	0.1%	0.1%	0.0%	0.0%	0.1%	0.0%	0.1%	0.0%	0.1%
Data Processing Services	0.4%	0.2%	0.6%	0.2%	0.4%	0.3%	0.4%	0.4%	0.1%
Computer Systems Design	1.1%	1.0%	0.8%	1.0%	1.4%	1.8%	0.8%	0.8%	0.8%
Scientific R&D in Physical, Engineering & Life Sciences (Taxable Only)	0.2%	0.4%	0.1%	0.0%	0.4%	0.3%	0.1%	0.1%	0.3%
Telecommunications	1.5%	1.1%	0.1%	1.0%	1.1%	0.0%	1.4%	1.3%	0.3%
Pharmaceuticals	0.3%	0.3%	0.8%	0.5%	0.3%	0.8%	0.3%	0.1%	0.1%
Basic Chemical Manufacturing	0.3%	0.1%	0.1%	0.2%	0.1%	0.4%	0.1%	0.6%	0.1%
Testing Laboratories	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
Total S&T	7.8%	8.9%	7.3%	4.9%	9.9%	5.0%	5.1%	5.9%	4.9%
All Sectors	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

D -- Information withheld to avoid disclosing data of individual companies; data are included in higher level totals
NA -- Numbers cannot be calculated because information has been withheld to avoid disclosing data of individual companies; data are included in higher level totals
Source: U.S. Economic Census, www.census.gov, retrieved Jan-March 2001.

Table A-2

Science and Technology Employment, Payroll Per Worker, 1997

	U.S. Total	CA	CT	IL	MA	NJ	NY	TX	WA
Aerospace	$51,642	$54,070	$54,223	$50,401	$52,534	$39,970	$44,358	$51,726	NA
Computers & Electronic Products	$42,812	$50,126	$41,466	$40,271	$48,085	$45,172	$41,066	$44,953	$47,682
Software Publishers	$69,025	$78,414	$79,134	$63,876	$65,199	$69,737	$77,970	$78,844	$97,498
Online Information Services	$47,181	$46,265	$44,461	$40,013	$57,278	$43,254	$30,081	$33,624	$44,311
Data Processing Services	$37,269	$37,521	$42,224	$33,236	$37,752	$45,644	$27,940	$47,071	$35,936
Computer Systems Design	$55,123	$61,463	$62,448	$57,832	$62,485	$62,548	$59,945	$56,050	$53,326
Scientific Research & Development in Physical, Engineering & Life Sciences (Taxable Only)	$83,160	$65,207	$68,723	$46,982	$68,636	$408,396	$55,930	$49,393	$51,876
Telecommunications	$46,972	$44,266	$14,420	$47,879	$47,387	$59,028	$55,323	$44,671	$51,770
Pharmaceuticals	$49,652	$51,362	$76,822	$57,564	$47,613	$57,379	$37,920	$45,605	$49,821
Basic Chemical Manufacturing	$51,380	$45,585	$49,847	$47,387	$48,405	$52,854	$50,446	$59,228	$55,156
Testing Laboratories	$33,024	$35,786	$37,452	$39,496	$38,091	$37,246	$35,842	$31,263	$33,888
Total S&T	$46,549	$52,847	$53,631	$48,443	$52,787	$74,933	$48,213	$48,790	$54,831
All Sectors	$26,311	$31,003	$34,379	$30,810	$33,147	$33,580	$36,903	$27,269	$29,362

NA -- Numbers cannot be calculated because information has been withheld to avoid disclosing data of individual companies; data are included in higher level totals

Source: U.S. Economic Census, www.census.gov, retrieved Jan-March 2001.

Table A-3
Computer Training Programs

# Programs Listed in California	Total	University Extension	Community College	Private College or University	Proprietary	Unknown
Novell	62	2	5	4	51	0
Oracle Certification	38	2	0	1	35	0
Cisco Certification	38	0	1	2	35	0
Visual Basic	63	2	0	1	60	0
Java	60	3	5	6	44	2
SQL	70	2	0	1	67	0
C/C++	112	3	6	6	94	2
MCSE Certification	91	2	0	2	87	0
Microsoft Certification	98	3	0	3	93	0

Source: Author's tabulations using data from www.computertrainingschools.com

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