California Report on the Environment for Science and Technology

California Council on Science and Technology

LETTER FROM CCST MEMBERS

California is the world's leader in advancing cutting-edge science and technology (S&T) research and in creating new technology enterprises. Despite this decade's defense cutbacks, today the state enjoys the benefits of a diversified economy built on high-tech industries.

But even as the state experiences a strong economic recovery, CCST members – who include leaders from industry and academia – are concerned whether California can maintain its S&T leadership in the face of increasing worldwide competition, and whether all Californians are benefiting from the state's resurgence.

Some important questions to answer: Are the people, capital and state governmental policies in place to respond to an evolving high-tech economy? What can leaders do to ensure that California's K-12 schools better prepare students for high-tech jobs? How will the state respond to increasing competition for federal funding in science and engineering research at California's colleges and universities?

CCST has taken the lead on addressing these pressing S&T issues, and commissioned California's Report on the Environment for Science and Technology (CREST), the first comprehensive report of the state's S&T indicators. Based on extensive research and analysis, this report summarizes the challenges the state faces in sustaining the S&T infrastructure, and offers recommendations for how industry leaders, academic planners and state policy makers can respond more effectively to a high-tech economy. CREST – which was launched in 1997 – is a natural outgrowth of CCST's commitment to S&T leadership, service and advocacy for California.

For this report, CCST identified 11 experts to head eight research projects. These researchers spent two years studying the state's government, industry, federal labs, foundations, K-12 schools, academic institutions, and venture capital firms, and have analyzed the ability of these institutions to help the state create and use new technology.

California is at a crucial point in its history. This report identifies the need for a strategic plan that engages both the public and the private sectors in addressing the state's S&T priorities. We present CREST to leaders from industry, academia and the state as a guide for how to maintain both California's S&T leadership and a quality of life Californians have come to expect.

Karl Pister, Board Chair

Paul C. Jennings, Council Chair

Bruce B. Darling,
S&T Infrastructure Committee Chair

Susan Hackwood, Executive Director

California Report on the Environment for Science and Technology

CREST

A Report Prepared by
The California Council on Science and Technology

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The California Council on Science and Technology is a nonprofit organization established in 1988 at the request of the California State Government and sponsored by the major post secondary institutions of California, in conjunction with leading private-sector firms. CCST's mission is to improve science and technology policy and application in California by proposing programs, conducting analyses, and helping government implement policies and initiatives for a better economy and quality of life.

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CREST HIGHLIGHTS

Sustaining California's Technology Miracle

This report, for the first time, assesses the present status and long-term trends affecting the science and technology infrastructure in California. The purpose of the report is to provide information, guidelines and recommendations for long-term planning with respect to policies that affect science and technology and to demonstrate the usefulness of in-depth analysis of the state's science and technology indicators.

California lacks a regularly executed strategic planning process. The CREST report fills a gap in the policy-making process in California and creates an opportunity to engage the state government in long-term planning. The report provides the essential information upon which specific strategic and tactical decisions can be made.

If supported, the technology miracle in California will continue to grow and fuel the economy. However, there is uncertainty as to what the role of the state government will be and whether all Californians will have the opportunity to share the benefits of these new industries.

California's science and technology infrastructure consists of its research-intensive industries, the research and development activities that sustain these industries, and the educational system that supplies these industries prospective employees and advances in fundamental knowledge.

The CREST report clearly demonstrates the importance of the high-tech industry to California's economy and its people. High-technology industries are responsible for a widely envied "California Technology Miracle." In California, 9.3 percent of all jobs are in high-technology industries, far above the national average of 5.6 percent. Average annual wages in high-technology industries are over $60,000, roughly double average pay in all private, non-farm industries. Research and development sustain these industries, and here again California leads the nation, with 20 percent of the nation's R&D compared to 12 percent of the U.S. population and 13 percent of the U.S. Gross Domestic Product.

The significance of the CREST report is that for the first time in California, the factors that make this technology miracle happen are clearly quantified and analyzed. However, to fulfil the promise of a great future, important changes must occur. Specific actions by the state government, industry and academia can now evolve from the CREST recommendations.

SUSTAINING CALIFORNIA'S TECHNOLOGY MIRACLE

The Miracle Is Centered in High-tech Industry

- The percentage of Californians in high-tech jobs is nearly twice the national average
- Annual wages in high-tech jobs are more than $60,000, nearly twice other non-farm industries
- California leads the world in the investment of high-tech venture capital

The Miracle Is Not Guaranteed

- California's research engine drives industry growth, but no longer has the lead it once had

The Miracle Is Not Benefiting All Californians

- A significantly growing number of Californians do not have the education preparation to enable them to benefit from job opportunities created by high-tech companies
- The number of Californians being educated with the skills necessary to meet employer needs is insufficient
- Many Californians graduating from K-12 and community college systems are not adequately prepared to enter the high-tech workforce

What Must Be Done

- State government must take a leadership role in sustaining California's high-tech future by supporting the science and technology infrastructure, by setting priorities in its R&D and by coordinating its research policies
- The problems of K-12 education must be addressed, K-12 classroom instruction and teacher training programs must enhance and expand emphasis on science and math education
- Science and technology education in community colleges and in the state's colleges and universities must be expanded

I. PROJECT SUMMARY

California is the world's leader in the creation of high technology industry and employment, and in the underlying research in science and technology. However, the infrastructure that has helped establish this status will not be adequate for future growth. The evolving high-tech industry has created the need for systemic changes to a number of areas, such as the way state government coordinates high-tech activities, the educational system, R&D incentives and the tax structure.

These are the main conclusions of a California Council on Science and Technology commissioned report entitled **CREST**, the **California Report on the Environment for Science and Technology**. CREST has analyzed the state's science and technology (S&T) infrastructure to determine if California has the people, capital investment and necessary state governmental policies to maintain California's leadership in the face of increasing worldwide competition.

Through eight individual research projects, CREST analyzes the state's ability to create and use new technology.

In its tradition of serving the leaders and people of California, CCST, through CREST, offers the following findings and recommendations to policy makers, industry leaders, academic planners and all who contribute to the state's S&T infrastructure.

Table 1. Summary of California S&T Infrastructure

Area/Topic	CREST Key Findings
Overall S&T Effort	Outstanding level of activity, but not all elements of the S&T infrastructure are adequate for future growth
High-Tech Industry	High level of R&D investment; however, there is a need for increased partnerships between industry and academia in order to expand the state's basic research base that industry relies on
Academic Research	Essential engine for innovation, excellent quality, but California is losing ground to other high-tech states in commercially crucial technology fields
State Science and Technology Policy	State R&D programs and R&D tax credit need strategic focus
Federal Labs	A major asset: better use should be made by state government and industry
Foundation Support	Opportunity to involve foundations in California S&T effort
Venture Capital	World leader in venture capital investments; opportunity to consider other early-stage funding methods for selected technology areas and small start-up companies
Labor Force	Essential to improve K-12 education, expand teacher education programs in CSU and UC, and focus California Community Colleges and others on the expansion of lifelong learning and skill development

Why Science and Technology Matters

For the better part of a century, science and technology has underpinned California's leadership in agriculture, aerospace and defense, electronics, computers, software, motion picture production, multimedia entertainment, biotechnology, medical devices, environmental technologies, and telecommunications. As shown in the table below, science- and technology-based industries constitute an unusually large, high-wage component of the California economy.

But this does not ensure future success. California's status as a high-tech leader is dependent upon the vitality of its schools, universities, federal laboratories, technology-based companies, and venture capital firms, as well as the commitment of its elected and appointed officials.

S&T EMPLOYMENT IN CALIFORNIA'S ECONOMY

Table 2. High-Tech Jobs, CY 1998

Industry	U.S. Total (thousands)	CA Total (thousands)	CA as % of U.S.
Computer Manufacturing & Data Processing	1,978	333	16.8%
Communications Equipment, Electronic Components, & Communications	2,431	367	15.1%
Aircraft & Missiles	612	114	18.6%
Scientific & Medical Instruments	1,138	228	20.0%
Pharmaceuticals	274	31	11.3%
Motion Pictures	564	186	33.0%
High Tech Total	6,997	1,259	18.0%
Nonfarm Total	125,832	13,584	10.8%

Source: Bureau of Labor Statistics, U.S. Department of Labor, http://stats.bls.gov/sahome.html, via links for "National Employment, Hours, and Earnings," and "State and Area Employment, Hours, and Earnings."

Project Summary - Findings and Recommendations

Over a two-year period the CREST researchers identified and analyzed science and technology indicators. Detailed descriptions of the findings and recommendations of the research projects are found in the body of the report. The following summary identifies the most significant findings and recommendations.

California R&D Activity

Summary: California conducts a prodigious amount of research and development. Its share of national R&D has held steady since 1989 despite substantial federal cutbacks, as private industry expansion has more than taken up the slack. California is also the world leader in venture capital investments. However, California's share of academic R&D is below its share of the national high-tech economy. Furthermore, industry funding of academic R&D is relatively low. The state's policy tools have the potential to provide substantive stimulus to S&T sector performance, but the state lacks the focus to achieve this. Multiple programs and departments within the state government have similar goals and objectives directed at improving the state's high-tech environment.

Recommendations: State government has the opportunity to develop a statewide science and technology strategy and therefore more effectively contribute to R&D in California. To make a significant impact, California's strategy needs targeted objectives designed to fill in gaps and weaknesses in areas where California already has technological strength among business, academia and federal laboratories.

- Implement a strategic planning process within state government that will ensure R&D funding allocation decisions are based on economic considerations.
- Coordinate disparate high-tech programs throughout the state government.
- Explore and pursue options that encourage industry to continue and expand support of university-based R&D.

California R&D Tax Credit

Summary: California's R&D income tax credit could provide a powerful incentive for technical R&D activity. However, requirements for substantial record keeping make it of limited use to fledgling companies.

Recommendations: State government has the opportunity to create an incentive structure for companies to invest in new business opportunities.

- Conduct an evaluation of the effectiveness of the R&D tax credit, using data on actual tax liabilities and credit claims.
- Explore and evaluate alternate measures to enhance industry's sustained investments in R&D.

California Academic Institutions' Performance

Summary: California's universities conduct very high-quality scientific and engineering research. However, the size of the state's universities science and engineering departments and the extent of their output have been falling relative to other high-tech states. California has lost important ground to Massachusetts in nearly every area of science and engineering, including the commercially crucial technology fields.

Recommendations: State government should improve and sustain higher-education funding levels.

- Advance policy initiatives and legislation intended to increase funding levels for academic support and R&D activities.
- Communicate with the California Congressional Delegation on the importance of sustaining and increasing federal support of the state's R&D activities at universities.

California K-12 Education Evaluation

Summary: Primary and secondary schools in California are not adequately preparing students for the high-tech workplace. This shortcoming is just as critical for students entering the labor force after high school as it is for college graduates. While these failings have not yet seriously impeded development of high-tech industry in California, if not corrected they will prevent those educated in California from fully capitalizing on future development.

Recommendations: State government should ensure that substantive changes are made at the K-12 level to improve the likelihood that students are prepared for high-tech careers when they graduate, and that they have the right combination of skills to satisfy employers.

- Ensure that K-12 students have a solid grounding in math, science and technical skills.
- Develop incentives that encourage K-12 students to pursue elementary and high school teaching careers.
- Expand teacher education programs in the CSU and UC systems.
- Impose reasonable minimum training requirements for public school teachers.
- Develop incentives that encourage teachers to pursue multiple subject certification and minimize out-of-subject teaching assignments.

California Supply and Demand of Skilled Workers

Summary: To enable Californians to experience the greatest benefit from the high-tech sector expansion, California must educate more of its own scientists, engineers, and skilled workers. The state must increase support for engineering, science, and agriculture undergraduate programs and terminal master's degree programs in these areas if California is going to meet the high-tech human resource needs of a growing science and technology economy. If California does not address this challenge, the state risks increasing the export of high-tech jobs and companies to other states.

Recommendations: The CREST report suggests three avenues for state policymakers to increase the "home grown" supply of science and technology workers. All are considered low risk because they prepare workers to respond to changes in demand, and have the added benefit of making California more attractive to skilled workers.

- Strengthen basic skills through improvements in K-12 education.
- Implement a public education and outreach program encouraging K-12 students to pursue careers in S&T.
- Focus California Community Colleges and other institutions on the expansion of life long learning and skill development.

II. INTRODUCTION

California is the nation's leading science and technology state. As such, science and technology have underpinned California's leadership in agriculture, aerospace and defense, electronics, computers, software, movie production, multimedia entertainment, biotechnology, medical devices, environmental technologies and telecommunications. This leadership provides jobs, sustains a high standard of living and offers innumerable other benefits to California residents.

California's leadership is dependent upon the vitality of its schools, universities, federal laboratories, technology-based companies, and venture capital firms, as well as upon the commitment of its elected officials. As this report will describe, in these areas California has many strengths on which to build. However, the infrastructure that has helped establish this status will not be adequate for future growth.

To better understand how the state should respond to the changing technology environment, the California Council on Science and Technology commissioned a comprehensive evaluation of California's high-tech infrastructure two years ago. Through eight individual research projects, CCST's California Report on the Environment for Science and Technology (CREST) has analyzed the state's science and technology infrastructure to determine if California has the people, capital investment and necessary state policies to maintain California's leadership in the face of increasing worldwide competition.

> ***"...research and development spending since the Second World War has accounted for a substantial part, perhaps between one-quarter and one-half, of the annual growth rate in productivity."***
>
> ***Joseph Stiglitz***
> ***Chair, Council of Economic Advisors to the President of the U.S., 1994***

To achieve this goal, CREST researchers have analyzed data on:

- federal, state, and industry research and development expenditures,
- science and technology research at California's universities and federal laboratories,
- California's R&D tax credit,
- private foundation support,
- venture capital, and
- K-12 education's preparation of students to work in the high-tech sector.

Through this comprehensive set of S&T performance indicators, informed evaluations and policy recommendations have been developed. The indicators are intended for use by industry leaders, academic planners and state and federal policy makers. Indicators are all subject to change over time and CCST plans to continue to produce and analyze these indicators as a part of future studies.

The main body of the CREST report consists of eight projects (summarized in Appendix A), conducted by eleven principal investigators (listed in Appendix B). Descriptions of the study findings are presented in this summary report. Within this set of indicators and the research projects that generated them, the CREST report has developed a broader and deeper analysis of the California high-tech sector than previous studies. This report provides an overview of the project findings and a discussion of the policy recommendations suggested by these findings.

III. WHY SCIENCE AND TECHNOLOGY MATTERS

California has traditionally been a trend-setter for the nation, a cultural, social, and economic frontier as well as a geographic one. California's position as a major developer and purveyor of high-tech goods and services fits perfectly with this image. Apart from appearances, the evidence is clear that science and technology is a dominant component of California's economy.

> ***"...technological entrepreneuring has been the main force behind our industrial development from the beginning. It is not today at its full power. We can and should accelerate it."***
>
> ***Simon Ramo, 1988***
>
> ***Recipient of the Presidential Medal of Freedom and Co-founder of TRW***

Technology Sectors Are An Extraordinarily Large Share Of The California Economy

The national and state job data presented in Table 3 shows 1998 average payroll jobs and California's share of U.S. jobs for a range of high-tech industries. As seen in the last column, California accounted for 10.8% of nationwide payroll jobs, but 18.0% of nationwide high-tech jobs (the sectors identified in Table 3). Notice also that California's job-share exceeds 10.8% in every one of these sectors. To put it differently, these sectors are much more prominent within the California economy than they are nationwide. Under this definition, high-tech accounts for 5.6% of U.S. jobs, but 9.3% of California jobs.

High-Tech Is High-Income

High-tech sectors provide a source of very high-income jobs for Californians. Through early 1998, high-tech wages in California averaged $60,100 per worker, compared to a $30,400 average payroll for all other private nonfarm industries. Table 4 summarizes data on average wages per worker for private-sector S&T industries. Furthermore, average wages exceed the rest-of-state average in every high-tech sector. They are especially high in computer programming, biotech and other sectors where employment is growing rapidly.

S&T EMPLOYMENT IN CALIFORNIA'S ECONOMY

Table 3. High-Tech Jobs, CY 1998

Industry	U.S. Total (thousands)	CA Total (thousands)	CA as % of U.S.
Computer Manufacturing & Data Processing	1,978	333	16.8%
Communications Equipment, Electronic Components, & Communications	2,431	367	15.1%
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Motion Pictures	564	186	33.0%
High Tech Total	6,997	1,259	18.0%
Nonfarm Total	125,832	13,584	10.8%

Source: Bureau of Labor Statistics, U.S. Department of Labor, http://stats.bls.gov/sahome.html, via links for "National Employment, Hours, and Earnings," and "State and Area Employment, Hours, and Earnings."

HIGH-TECH IS HIGH-INCOME

Table 4. Average Wages, S&T Sectors, 1997-98

Industry	Wages/Worker
Pharmaceuticals	$55,162
Computer Manufacturing	$77,818
Consumer Electronics	$50,908
Communications	$52,176
Motion Pictures	$69,594
Commercial Biological Research	$68,737
All High-Tech Industries	$60,136
All Other Non-Farm Industries	$30,443

Source: Calif. EDD, ES-202 Data, Private Establishments. Average wages in each industry—and for high-tech and the rest-of-economy aggregates—are defined as total annual payrolls divided by annual averages of payroll employment. Data listed cover the four-quarters ending Q2 1998, the latest for which data are presently available.

High-Tech Set the Pace for California's Recovery of the Mid-1990's

The importance of technology to California is also evident when considering the overall condition of the state economy. The state has recovered well from its 1990-93 recession. Much or most of the strength of this rebound can be directly traced to high-tech industries. As shown in Table 5, many of these sectors have enjoyed much faster growth since late 1993 than has the state's economy as a whole. Furthermore, average growth rates in high-tech sector jobs and wages far exceed those in the rest of California.

S&T SECTORS LEAD CALIFORNIA EXPANSION

Table 5. 1994-98 Growth, California High-Tech Jobs

Industry	1994-98 Average Growth	
	Jobs	Average Wages
Pharmaceuticals	2.1%	7.5%
Computer Manufacturing	3.4%	8.8%
Consumer Electronics	3.0%	12.0%
Communications	2.4%	8.9%
Motion Pictures	5.9%	11.6%
Commercial Biological Research	3.6%	6.5%
High Tech Totals	4.1%	4.9%
All Other Non-Farm California Totals	1.6%	3.0%

Source: California EDD, ES-202 data, Private-sector establishments. Growth rates are for four quarters ending in 1998:II versus CY 1994.

S&T sectors have played a lead role in the economic recovery that has occurred in recent years. Given the high-income nature of S&T jobs, high-tech sectors offer the best chance for California's economy to continue its upward swing.

S&T industries provide a California-livable wage, not only for entrepreneurs enjoying income from stock options and IPOs, but also for line workers earning an hourly wage. This is already evident from the data presented above. It will be further detailed below when occupational employment and wage data for S&T sectors are discussed.

The high incomes earned in S&T sectors also benefit other Californians by generating tax revenue for state and local governments. Social service benefit levels and total public expenditures on social services per capita in California are among the highest in the nation. So are per capita California government expenditure levels. Continued growth in high-income industries is essential for retaining current levels of public services.

Summarizing why science and technology matters:

1) Science- and technology-based industries constitute an unusually large, high-wage component of the California economy.

2) California's recovery from the recession of the early 1990s was accelerated by the rapid growth of science and technology sectors, and continued growth in these industries is essential if California is to sustain satisfactory growth.

3) A large, extremely diverse state such as California requires a diversified economic base, and technology is an essential element of a strong economy.

4) The high-benefit nature of California government and high cost of living in California dictate an intense participation in S&T sectors in order to support adequate public services.

These points illustrate the importance of a vital, growing high-tech sector for California. What, then, is the status of this sector in California? The next section addresses this question by analyzing private-sector, local, state, and federal government performance, utilizing CREST project findings.

This section provides an integrated overview of the report findings. Section V details California's R&D resources and assesses science and technology performance measures. Section VI integrates these findings into an overview of S&T commercialization ranging from basic scientific inquiry to bringing high-tech goods and services to market. Finally, Section VII provides some further perspective, discussing the issue of California as a high-cost state.

High-tech industries are a much larger component of the California economy than is the case nationwide. These industries provide both higher-paying jobs and a faster growing job base than in the rest of the state's economy. Future economic growth is vital for the state's well being, and it is quite unlikely that such growth can be achieved without satisfactory contributions from high-tech sectors.

Table 6 provides a snap-shot summary of the report findings.

Private-sector aspects of S&T are performing well. Private, high-tech companies in California underwent a massive expansion in the 1990s. This expansion has been seen in the outstanding performance in patents awarded, an extraordinary share of venture capital funding activity, and rapid growth in high-tech jobs and incomes.

Table 6. Summary of California S&T Infrastructure

Area/Topic	CREST Key Findings
Overall S&T Effort	Outstanding level of activity, but not all elements of the S&T infrastructure are adequate for future growth
High-Tech Industry	High level of R&D investment; however, there is a need for increased partnerships between industry and academia in order to expand the state's basic research base that industry relies on
Academic Research	Essential engine for innovation, excellent quality, but California is losing ground to other high-tech states in commercially crucial technology fields
State Science and Technology Policy	State R&D programs and R&D tax credit need strategic focus
Federal Labs	A major asset: better use should be made by state government and industry
Foundation Support	Opportunity to involve foundations in California S&T effort
Venture Capital	World leader in venture capital investments; opportunity to consider other early-stage funding methods for selected technology areas and small start-up companies
Labor Force	Essential to improve K-12 education, expand teacher education programs in CSU and UC, and focus California Community Colleges and others on the expansion of lifelong learning and skill development

State and local level government support of the high-tech sector has been less than satisfactory. California's primary and secondary schools are not performing adequately. In years to come, unless the issue of worker skills is addressed now in K-12 schools, in community colleges, in four-year colleges, in universities, and in adult education programs, it is likely that firms will find it less attractive to locate in California or they will be forced to move some of their operations to other states or overseas in order to obtain the workers they need. State incentives for development of high-tech enterprise need to be strategically organized and coordinated by lawmakers working with industry and academia to achieve their full potential. Finally, while California's academic science and technology is of outstanding quality, the overall size of research activities in California universities is only average in relation to the state's population and income.

Since the end of the Cold War, the federal government has severely cut its support of S&T in California. However, the state still boasts an impressive array of federal labs, whose operating budgets have held up reasonably well despite declining defense appropriations. While there are practical limitations on the extent to which these labs can interact with California companies and agencies, these limits are surely not being tested in California.

In terms of the stages of commercialization, California companies perform well at the early (basic and applied research) and middle (development and commercialization) stages. R&D levels are high and growing, product development is excellent and access to venture capital is unparalleled. The innovation and breakthrough accomplishments that generate new industry are generally produced by the top-rated departments and research labs. Although of high quality, the quantity of university and research lab output and the number of science and engineering graduates are insufficient to support future industry growth. There also is need for prioritizing state research activities. With California high-tech companies now prospering, there is reason to call upon them to exert greater leadership in promoting expanded partnerships among state agencies, industry, universities, and foundations.

At the final stage of production and marketing, current conditions are satisfactory, but there are questions concerning the sustainability of this performance. The demand for workers could soon outpace the supply of skilled California workers. In this regard, the debate about whether there is a labor shortage misses the point. Labor markets will function. However, in order to insure that market allocations provide favorable shares of jobs and wage-levels to Californians, the performance problems of California primary/secondary schools, community colleges, and to some extent, teaching universities and adult education programs need to be addressed.

Finally, while California's cost of living is often cited as an impediment to development, it is, in fact, an indication of the desirability of California's economic prosperity and lifestyle. If we can keep state institutions responsive and state tax burdens reasonable, the higher cost of living will not be a drag on economic development.

Section III described California's rapid high-tech growth, so it should be no surprise that most aspects of these sectors are performing well. Not only are S&T sectors growing, but the evidence also suggests that private industry is supporting its own S&T research growth. This section details California's S&T resources by describing industry, federal, state, venture capital, and foundation support of science and technology and the supply of and demand for skilled workers. Performance measures of science and technology are assessed by analyzing inventor activity, performance of academic institutions, performance of K-12, and performance of federal labs.

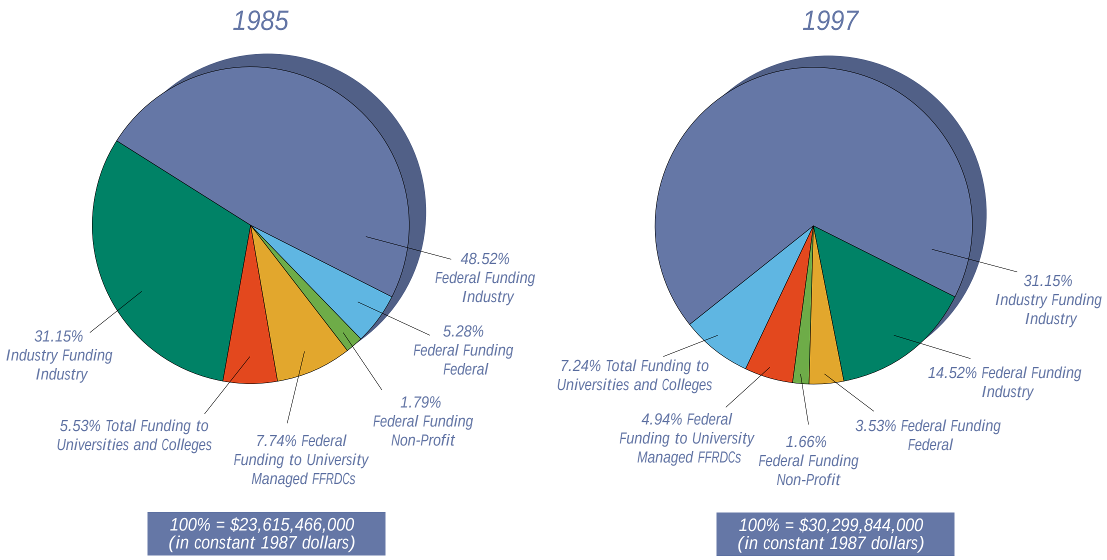
R&D expenditures in California increased between 1975 and 1995 from $7 billion to $41 billion. Correcting for inflation, expenditures doubled, and represent disproportionate R&D activities relative to the rest of the United States. The relative population of California increased slightly over the past 20 years, from 11.3% to 12.1% of the U.S. population. Between 1977 and 1991, California's share of the U.S. economy grew from 11.6% to nearly 14%. California's Gross State Product (GSP) was 12.75% of the Gross Domestic Product (GDP) in 1997.

The importance of science and technology to Californians is revealed in the state's share of national research and development. In 1997, California accounted for nearly 20% of total U.S. R&D. California's share of the total R&D budget for the country has been near 20% for the last 15 years, with a slight increase during the late 1980s. Michigan, currently the second largest R&D conducting state, conducts 7.25% of the country's R&D (all figures for 1995); New York has fallen from second place in the early 1980s to third place in 1995, at 6%; followed by Massachusetts, New Jersey, Texas, Illinois, Pennsylvania, Ohio, and Washington (the newcomer on the top ten list).

Of course, California is the most populous state, but its per capita R&D is also very high. The best indicator of R&D intensity is the ratio of state R&D expenditures to gross state product. California with 20% of national R&D, accounts for 12% of the U.S. population and approximately 13% of U.S. gross domestic product. Thus, California's R&D effort is roughly 50% greater per capita and per dollars than the U.S. average. Among the top ten R&D states, only Michigan and Massachusetts have higher per capita R&D effort. For the past 15 years, R&D has in most years comprised more than 4% of GSP in California. Not only is this substantially higher than the U.S. average, it is also higher than the R&D effort of any nation including Japan or Germany.

Chart 1 shows the change in R&D funding distribution by performing sector from 1985 to 1997. These changes are discussed in the next section.

Chart 1. California R&D Expenditures Performing and Funding Sectors 1985-1997



Source: Cohen [1]

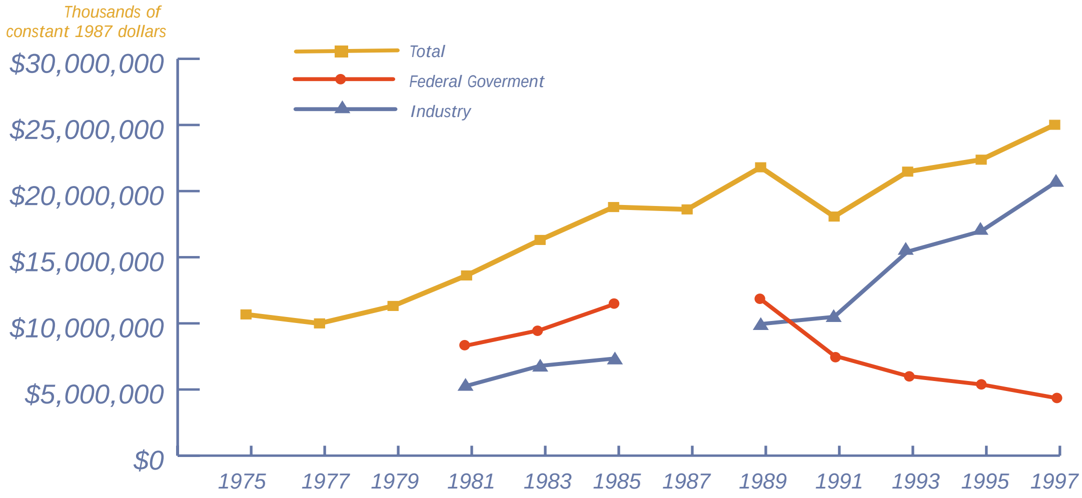
V.1.1 INDUSTRY SUPPORT OF R&D

The 1990s have seen a dramatic shift in support of California's R&D activity. Throughout the last decade, California R&D has retained an extraordinarily strong, 20+% share of nationwide totals. [1] Compare this to California's 11% share of total U.S. jobs, 13% share of Gross Domestic Product, and 18% share of high-tech jobs. Thanks to a surge in privately funded R&D, California R&D has held this share despite a near-collapse in defense-related activity.

> ***"Recently, industry took the lead in California in both performing R&D and in paying for it."***
>
> ***Linda Cohen***
> ***University of California, Irvine***

In inflation-adjusted terms, industry-financed industrial R&D grew 8.7% per year over 1981-1995. As shown in Chart 2, over 1989-1995, when federal cuts were most severe, industry-financed R&D grew even faster, at a 9.3% rate. These increases fully offset the cuts in federally financed activity. As of 1997, private industry funded 82% of industrial R&D and 68% of all R&D in California, up from 46% and 35%, respectively, in 1989.

Chart 2. R&D Expenditures in California Industries – Broken Down by Source of Funds



Source: Cohen [1]

Table 7 reports the distribution of major high-tech industry-performed R&D in California and in the U.S. This includes industry-supported and government-supported activities. Similar to the rest of the country, about three-quarters of industry R&D takes place in the manufacturing sector. Within the manufacturing sector, California disproportionately emphasizes the electrical equipment category (24%) and the transportation equipment category (31%) which includes aircraft and missiles. In the service sector, the emphases are on computer and data processing (8%) and engineering and management services (8%). These numbers underscore the extent to which information technology dominates the California industry R&D. The R&D intensivity measure is the ratio of R&D expenditures to GSP. The final column in Table 7 presents California's share of total U.S. industry R&D.

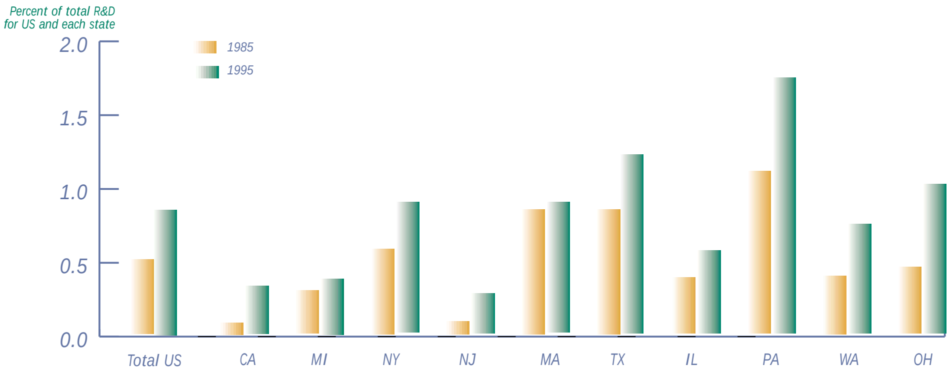
While industry has sharply raised its own R&D activity in California, its support of California university research still lags behind other high tech states (see Chart 3 which compares industry support as a share of that state's total R&D). Industry has raised its share of support of California universities and colleges research from .1% in 1981 to .39% in 1997 as a share of California's total R&D. [3] However, this share, even when converted to a share of the U.S. total R&D, is still far below California's share of national S&T activity as shown by Californians share of high-tech jobs, 18% vs 12% of U.S. population. As will be discussed later, more active support by private companies, as well as state agencies, would help improve the competitive position of California academe by improving the quantity of high-quality research.

Table 7. Major R&D Performing Industries in California - 1995

INDUSTRY	% CA GSP	% Industry R&D in CA	R&D Intensivity	% US R&D IN CA
All Manufacturing	14.00%	78%	18%	22%
Electrical Equipment	2.32%	24%	33%	36%
Electronics		17%		
Transportation	1.27%	31%	80%	27%
Aircraft & Missiles		18%		30%
Chemicals	0.90%	5%	17%	8%
Drugs & Medicine		4%		10%
All Services	22.08%	16%	2%	26%
Business Services	4.55%	8%	1%	25%
Computer & Data Processing		8%		25%
Engineering and Management Services		8%		29%

Source: Cohen [1]

Chart 3. Industry Funding to Universities and Colleges



Source: Cohen [1]

Evaluation Of California R&D Activity

Summary: California conducts a prodigious amount of research and development. Its share of national R&D has held steady since 1989 despite substantial federal cutbacks, as private industry expansion has more than taken up the slack. However, the California share of academic R&D is below its share of the national high-tech economy. Furthermore, industry funding of academic R&D is relatively low.

Recommendations: State government, industry and academia have several options to address the challenges surrounding R&D activities.

- **Explore and pursue options that encourage industry to continue and expand support of university-based R&D.**
- **Augment state funding for future R&D activity.**
- **Encourage California congressional delegation to support and preserve the state's share of federal budget allocations.**

V.1.2 FEDERAL GOVERNMENT SUPPORT

The federal government affects California's S&T environment in two ways. It affects scientific activity and industry through direct funding, and its tax and regulatory codes affect the way California companies and workers operate. The latter effects vary little from state to state and are, in any case, outside the purview of state policy. With respect to direct expenditures, three types are most relevant to California science and technology: direct support of research, direct purchases for defense and space, and the operations of federal labs.

In 1985 the federal government paid for 66% of the R&D performed in California, compared to 46% nation wide. By 1997 the amount the federal government paid for R&D performed in California had declined to 30%, while it had declined to 28% at the national level.

In 1989, prior to the onset of the federal budget cuts, especially defense cuts, 25% of national defense spending was allocated to California companies and military bases. This more-than-proportionate share alone would have been enough to deal California an especially sharp blow from federal defense cuts. However, defense appropriations to California were cut even more sharply than the nationwide average.

In contrast to these dramatic cuts in direct defense outlays, operations at California's federal labs have continued relatively unscathed. California boasts the operation of 48 federal labs, a far greater share than any other state. In 1997, R&D expenditures at federally funded research and development centers (FFRDCs) totaled $2 billion. These outlays have remained almost flat since 1989, but they have declined 32% in real terms. More to the point, they account for 55% of national totals. This is up from 50% in 1989, and it is a staggering share of federal activity (and it is still sharply higher than the 34% share in place prior to the defense build-up in the late 1970s and early 1980s). [1]

Federal agencies obligated close to $2 billion to California universities and colleges in 1997. Over half of this was from the National Institutes of Health (NIH), the largest supporter of academic research among the federal agencies. Next in importance to California institutions is NSF (about 18%), then The Department of Defense (DOD) (11%) and NASA (about 8%). California universities and colleges receive a very large share of the academic support budget of NASA (over 20% throughout the past twenty years). The DOD appears to have maintained a steady share of support to academia since 1991, in contrast to its actions in industry support. The California share of the budgets of the two largest supporters of academic research, NIH and NSF, has been somewhat larger on a per capita basis than the average for the country; between 14 and 15% in most years.

Evaluation Of Federal Government Supported R&D in the State

Summary: California has enjoyed a disproportionate share of federal R&D support for the past 15 years, but the share as well as the level has declined.

Recommendation: Communicate with the California Congressional Delegation on the importance of sustaining federal support of R&D activities in the state.

V.1.3 STATE GOVERNMENT SUPPORT

State policy has the potential to provide substantive stimulus to S&T sector performance, but the state lacks the focus to achieve this. Similarly, the state needs to push harder toward primary and secondary school reform if future California high-tech development is to proceed expeditiously. To establish these points, project findings in the areas of state-supported R&D, academic R&D, the California R&D income-tax credit, and student/teacher performance in primary and secondary schools and colleges are used.

Table 8. R&D Activity Supported by the State of California*
(dollars in millions)

	FY1994-95	Y1995-96	FY1996-97
Basic Research	$147.7	$152.9	$161.7
Applied research	$83.7	$87.4	$96.7
Development	$48.4	$27.7	$28.0
Commercialization	$23.0	$45.4	$29.6
Total Outlays	$302.8	$313.4	$316.0

*Approximately 98 to 99% of the total.
Source: Koehler Jones [3]

Table 9. State R&D by Field, FY 1995-96

	Outlays (in millions)	% of Total
Biological Science	$89.3	28.1%
Medical Science	$21.5	6.8%
Psychology	$2.3	0.7%
Physical Sciences	$29.6	9.3%
Environmental Sciences	$29.3	9.2%
Mathematics/Computer Science	$6.9	2.2%
Engineering	$63.3	19.9%
Social Sciences	$34.4	10.8%
Other science, not classified	$41.2	13.0%

Source: Chapman [2]

A comprehensive survey of R&D activity supported by the state government was undertaken. [2, 3] State Government is estimated to have sponsored over $316 million of R&D activity in fiscal year 1996-97. More than 50% of this budget was direct funding for the University of California system. About 63% of state-supported R&D was performed by academic institutions, 13.5% by state agencies, 6% by local governments, 9% by private industry, and 9% by nonprofit organizations. Of these expenditures, 86% were directly funded by the state and 11% by the federal government.

Most state-supported research concerned the initial stages of study, 48% of the total going to basic research and 30% to applied research (Table 8). State R&D funds were spread fairly widely across technical fields (Table 9). Biological sciences received the largest share at 28%, followed by engineering at 20%, "other" sciences 13%, social sciences 11%, physical sciences 9%, environmental sciences 9%, and medical sciences 7%.

Of the state's approximate $300+ million R&D funding, nearly 80% appeared to support early-stage R&D outlays. This has the potential to significantly shape early-stage R&D. Rather than concentrating activity in areas that have proved fruitful in the past or which otherwise offer exceptional promise presently, funds appear to be distributed more or less evenly to different political constituencies. There is insufficient strategy or structure behind this research effort.

"Allocation decisions may be more of a function of the political process than of economic analysis."

Jeffrey I. Chapman
University of Southern California

Furthermore, state-supported R&D activity levels have been stagnant. As will be discussed later, the Koehler Jones database tracks state R&D from FY 1994-95 through FY 1996-97. Over those three years, total R&D outlays were roughly flat, barely rising with inflation (Table 8). Without steady increases in funding, state R&D will become a progressively smaller component of California science.

State support of R&D as a percentage of total R&D spending in California is approximately 0.3%. By comparison, most other high-tech states spend significantly higher percentages, e.g., Texas, Illinois, and Pennsylvania. A point to note is state support in Massachusetts and New York are also low, 0.12% and 0.24% respectively. Nevertheless, California ranks 32nd in the nation for total state R&D support per capita.

Evaluation of California State-Supported R&D

Summary: Although not as high as in other high-tech states, the state supports a considerable amount of research in a variety of fields. Most of this is performed by universities and colleges and falls within the realm of basic and applied research. The composition of outlays suggests allocations are not based on economic considerations that follow a strategic planning process. Furthermore, state-supported R&D outlays failed to grow over the years of the study.

Recommendations: State government has the opportunity to develop a statewide science and technology strategy and therefore more effectively contribute to R&D in California. To make a significant impact, California's strategy needs targeted objectives designed to fill in gaps and weaknesses in areas where California already has technological strength among business, academia, and federal laboratories.

- **Implement a strategic planning process within state government that will ensure R&D funding allocation decisions are based on economic considerations.**
- **Coordinate disparate high-tech programs throughout the state government. Multiple programs and departments within the state government have similar goals and activities directed at improving the state's high-tech environment.**

California, along with 22 other states, supplements the 20% federal R&D tax credit with a 12% credit against state income taxes. The qualifications for the California credit generally conform with those for the federal credit. This relieves potential claimants from most of the burden of having to conform to two different sets of qualifying regulations. At the same time, it limits the ability of the state to reform its offerings of financial assistance.

The existing record-keeping and compliance requirements for the credit can be quite onerous for smaller firms. However, if the state were to reform its requirements, the situation could only become worse, because claimants would still have to comply with existing federal burdens as well as with reformed California requirements. The utility of the credit to start-up companies is also limited by the fact that these companies typically do not have substantial income tax liabilities against which to charge the credit, though they do have potentially large R&D requirements.

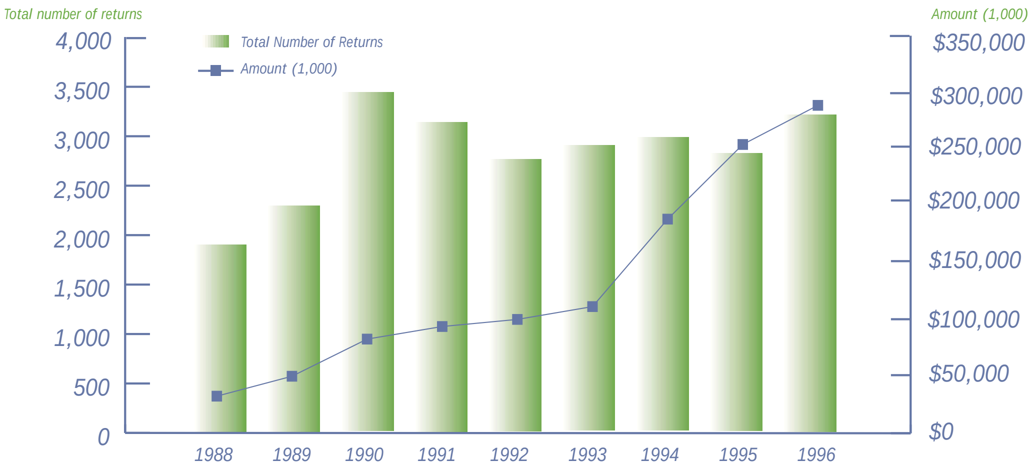
"California R&D tax credit...rules seem excessively complex and hard to plan for."

Bronwyn H. Hall

University of California, Berkeley

In 1996, the most recent year for which tax-return data are available, the R&D tax credit was claimed on 3,215 returns, with total credits claimed of $290 million (see Chart 4). Hall [4] finds that upon allowing for the effects of compliance rules, the state R&D tax credit reduces the after-tax costs of incremental R&D outlays by $0.07 per dollar of expenditure. This supplements the effective federal credit of $0.13 per dollar expenditure.

Chart 4. Total R&D Credit Claimed in California



Source: Hall [4]

Between 1988 and 1996, the number of returns claiming the credit has risen by about 70%, and total credits claimed have grown by 625%. At present, the California R&D tax credit constitutes a tax expenditure equivalent to about 5% of state corporate income tax revenues. Counting these tax expenditures as state "support" for R&D, they account for a bit less than 1.5% of privately sponsored R&D in California.

An in-depth evaluation of the effectiveness of the California R&D tax credit is outside the scope of this study. Enough questions have been raised about its effectiveness here that such a study should be considered. At a minimum, the state government should consider possible supplementation/substitution of the credit with incentives designed for start-up companies. Similarly, it would also be advisable for the state to coordinate its tax credit with its own efforts at R&D and with other commercial policy.

Evaluation Of State R&D Tax Credit Summary

Summary: California's R&D income tax credit could provide a powerful incentive for technical R&D activity. However, requirements for substantial record keeping make it of limited use to fledgling companies.

Recommendations: State government has the opportunity to create an incentive structure for companies to invest in new business opportunities.

- **Conduct an evaluation of the effectiveness of the R&D tax credit, using data on actual tax liabilities and credit claims.**
- **Explore and evaluate alternate measures to enhance industry's sustained investments in R&D.**

V.1.4 VENTURE CAPITAL

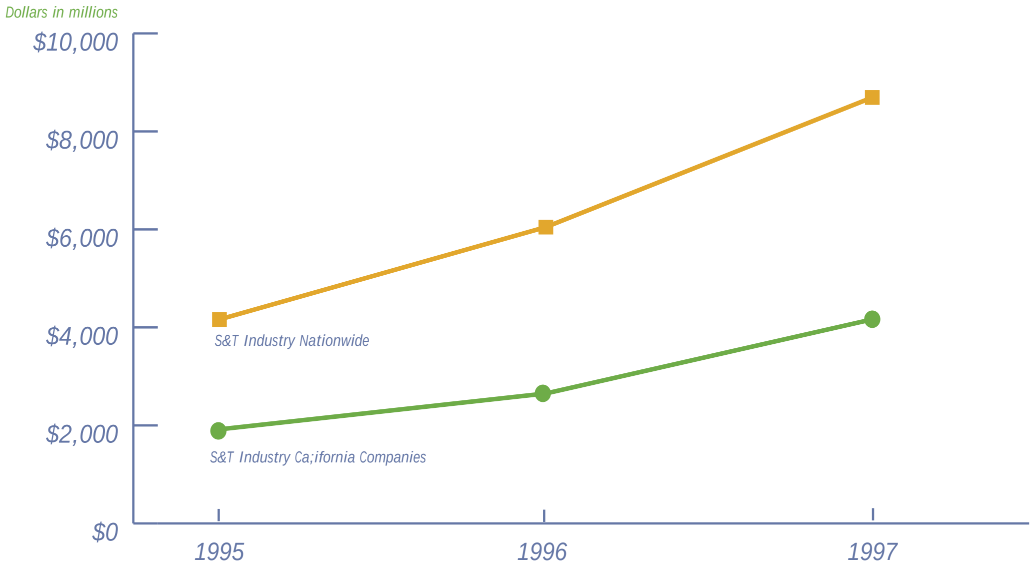
One requirement for continued growth is the availability of funding for the utilization of scientific advance. The CREST report directly investigated the incidence of venture capital (VC) funding for fledgling S&T companies.

Venture capitalists provide equity funding for companies whose operations are not mature enough to attract sufficient funding from commercial or investment banks or from issuing publicly traded stock. Their investments will typically be in place for no more than three to five years, during which time the venture capitalists face the prospects of a very high, or very low, return on their investment.

The evidence indicates that venture capitalists find California companies to be well worth these risks. VC support to California companies is a large and a growing share of nationwide levels. Moreover, California VC funds tend to be more concentrated in S&T industries than is the case nationwide. Chart 5 shows S&T industry total VC funding in the U.S. more than doubled between 1995 and 1998 and doubled in California. [5] In the process, California companies' share of U.S. VC funding rose to 37.6% through CY 1997.

> ***"Venture capital flows have increasingly favored California...California companies have access to the entire U.S. venture capital market. Conversely, the California venture capital market does not appear to be open to non-California start-up companies."***
>
> ***Michael T.K. Horvath***
> ***Stanford University***

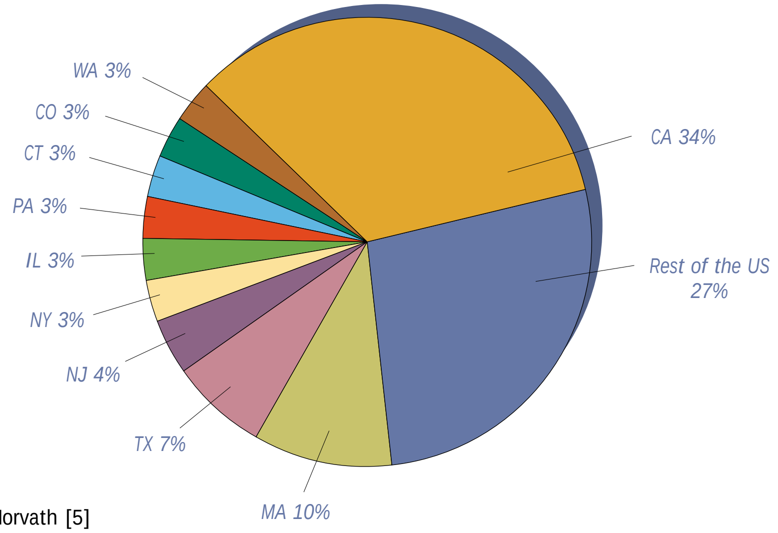
Chart 5. Venture Capital Flows



Source: Horvath [5]

Science- and technology-based industries represent a much larger portion of California VC (well over 80%) than is the case nationwide (about 65%). California's share of nationwide S&T venture capital increased over 1995-97. Chart 6 shows the percentage of VC support flowing to each state. California received 34% of the total national VC funds. Massachusetts received around 10% while Texas received 7%. New Jersey, New York, Illinois, Pennsylvania, Connecticut, Colorado and Washington received 3 to 4% each. [5]

Chart 6. Percent of U.S. Total VC Flows 1995-1998 Q1 (over $33 Billion)



Source: Horvath [5]

Once again, California's share of these flows is far larger than its shares even of S&T sector employment. Furthermore, the data indicate that California firms receive a disproportionately large share of funds from non-California VC companies as well as from California VCs. Over the 1995-98 period, non-California firms placed over 30% of their funds with California investees, while California firms placed nearly 70% of their funds in California.

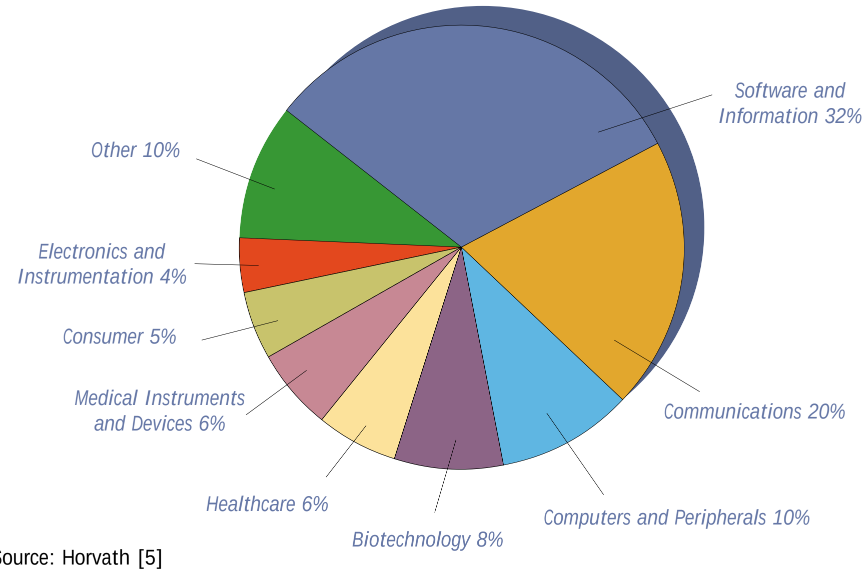
Within specific industries, 23% of all venture capital funds nationwide over 1995-98 went to information technology firms, 21% to communications and communications equipment, and 10% to health care, with smaller shares allocated to other industries. Within California, as shown in Chart 7, the industry concentration was even more extreme, with information technology garnering 32% of VC flows, communications 20%, computers and peripherals 10%, and biotechnology 8%. Again, high-tech industries garnered much larger shares of VC flows within California than they did nationwide.

Not surprisingly, Santa Clara County firms have accounted for an extraordinarily large share of venture capital coming to California companies. While other regions have recently begun to experience faster growth in VC funds flows, Silicon Valley firms continue to receive nearly half of California VC, with this share actually rising from 1995 through 1997.

This evidence suggests that California companies' access to VC funding is exceptional. A California start-up company with a potentially viable product or process has a greater chance of obtaining early-stage funding from venture capital companies than its counterparts in any other state.

The situation is less spectacular at earlier levels of development. Performing basic or even applied research with an eye toward future commercialization is too risky a proposition for venture capitalists. Hence this level of activity tends to be funded by various benefactors, e.g., angel capitalists, and by government. Government and university funding activity was discussed earlier, and it has already been noted that federal funding for research has dropped abruptly in this decade.

Chart 7. Percent of California Total VC Flows 1995:1998Q1 (over $11 Billion)



Source: Horvath [5]

Evaluation Of California Venture Capital Activity

Summary: From any perspective, California companies have remarkably high access to venture capital funding. This is a huge advantage for California companies over their competitors in other states.

Recommendations: While California companies have ready access to venture capital funding, seed funding is not as readily accessible.

- **Basic and applied research should be boosted to maintain pipeline.**
- **State and county government and other stakeholders should collaborate with venture capitalists to further encourage seed funding for start-up companies.**

V.1.5 FOUNDATION SUPPORT

Private foundations are another source of early research money focused mainly at universities and colleges. In the U.S., there were over 40,000 private charitable foundations in 1995 [6], with annual total grants exceeding $12 billion and total endowments in excess of $227 billion. About $600 million in grants (4.8% of total dollars) were made to science and technology in 1995.

Foundation grants to California scientists and engineers in 1995 totaled about $112 million, nearly 20% of the national total. This accounts for less than 0.3% of all R&D expenditures in California in that year. However, it accounts for about 14% of non-federal funding for research conducted outside industry and the federal government. Foundations, therefore, are a substantial funding source for basic and applied research.

The data indicate that foundation support could be augmented. No significant increase in foundation support was found for science or technology between 1991-95, despite a sharp growth in foundation endowments due to the booming stock market. Furthermore, total science and technology grants to the U.S. as a whole by California foundations appear to exceed grants received by California researchers. This suggests that California S&T recipients are under-served by the foundation community. Finally, foundation grants for science and technology account for only 5% of all foundation support.

On all these grounds, it would appear that there is room for expanded foundation support of California R&D at the basic and applied research stages (university and non profit sectors).

Many California foundations were established from the profits and income of technology giants, whose growth was made possible by the support they received early on. Owners of these companies have ploughed some of their gains back into foundations supporting scientific and other activity. It is time for the "success stories" of the last 20 years to take the leadership in expanding the number and the endowments of private foundations and in encouraging those institutions to support science and technology in California.

Evaluation Of Private Foundation Activity

Summary: Foundation support of science has not kept up even with the pace of inflation, let alone with foundation endowments. Also, California researchers appear to be under-served by foundations.

Recommendations: The foundation community has the opportunity to expand foundation support of California R&D at the basic and applied research stages (university and non profit sectors).

- **Raise awareness of California needs to foundations that support science and technology.**
- **Encourage high-tech industry leaders to take the leadership in expanding the number and the endowments of private foundations and in encouraging, along with other stakeholders, those institutions to support science and technology in California.**

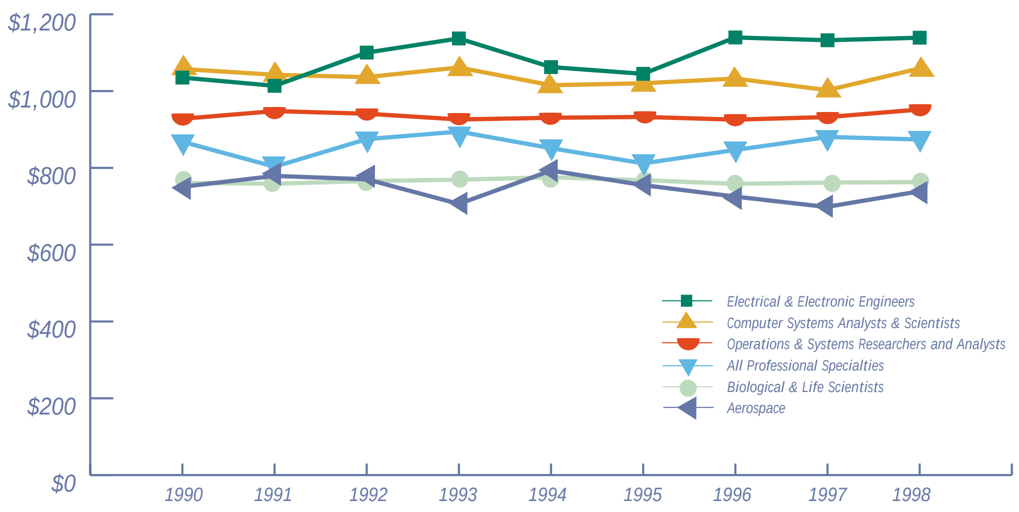
V.1.6 SUPPLY AND DEMAND OF SKILLED LABOR

The remaining aspect of private-sector S&T industry resources is the labor market. It is often claimed that there is a shortage of skilled workers in California. The term "shortage" has a very specific meaning to economists. It describes a malfunctioning market where the market fails to equate demand and supply at the equilibrium market price.

Not surprisingly, within this narrow, technical definition, this study has not found reliable evidence of a skilled labor shortage in California. Furthermore, the evidence is mixed as to whether market wages for technical jobs are rising significantly faster than those for the economy as a whole.

Chart 8 presents data on wages for high-tech industries [7] and shows average hourly wages in some sectors rising faster than are wages in general. However, data for wages by occupation show skilled S&T occupations wages rising no more rapidly than are wages for non-technical, knowledge-based positions. In terms of the economic definition, there does not appear to be a true shortage of skilled labor.

Chart 8. Median Weekly Wages (1998 dollars)



Source: United States Department of Labor, Employment and Earnings, Annual Household Averages

However, this does not mean that conditions are satisfactory. While labor markets are functioning, there are many "market solutions" which may be unacceptable to Californians and California policy-makers. An exportation of all future high-tech jobs and plants to out-of-state workers would be consistent with market function. Similarly, the importation of foreign workers to fill all or most new high-tech jobs would also be consistent with effective market function. However, given the discussion and points in Section III, both of these outcomes would likely be and should be unacceptable to Californians.

Again, the debate about whether there is a skilled labor shortage misses the point. The real issue is whether our educational system is effectively providing students with the technical and basic skills to allow them to compete effectively for the high-tech jobs that are being created.

> ***"To avoid losing its position as leader in science and technology, California must address the educational shortcomings that constrain the supply of labor in these industries."***
>
> ***Cecilia A. Conrad***
> ***Pomona College***

On these grounds, there is ample cause for concern, ranging from substandard math and science student test scores to lack of proper credentials among primary and secondary school teachers to even a perception among employers of inadequate personal skills and work ethics among job-market entrants. These issues are the product of the performance of state and local government.

The private-sector S&T base in California is performing well. It has fully taken up the slack created by post-Cold War budget cuts. It has led and paced the California economic recovery that has occurred over the last five years. Continuing intensive research and development activity levels indicate that the private sector in California is poised to lead the way into the next century. However, the shortcomings in California's ability to produce skilled labor will inhibit the future performance of California private-sector, high-tech companies.

Evaluation of Supply and Demand of Skilled Workers

Summary: To enable Californians to experience the greatest benefit from the high-tech sector expansion, California must educate more of its own scientists, engineers and skilled workers. The state must increase support for engineering, science, and agriculture undergraduate programs and terminal master's degree programs in these areas if California is going to meet the high-tech human resource needs of a growing science and technology economy. If California does not address this challenge, the state risks increasing the export of high-tech jobs and companies to other states.

Recommendations: The CREST report suggests three avenues for state policymakers to increase the "home grown" supply of science and technology workers. All are considered low risk because they prepare workers to respond to changes in demand, and have the added benefit of making California more attractive to skilled workers.

- **Strengthen basic skills through improvements in K-12 education.**
- **Implement a public education and outreach program encouraging K-12 students to pursue careers in S&T.**
- **Focus California Community Colleges and other institutions on the expansion of lifelong learning and skill development.**

V.2 PERFORMANCE MEASURES OF S&T IN CALIFORNIA

V.2.1 PATENTS

To be a leader in science and technology, a state must have a strong base of high-quality, inventive activity. Patents are indicators of scientific and technological discovery, of intellectual property rights, and of university, non profit, and commercial research productivity. In many, but not all, high-tech fields, patents lie at the nexus of the science and/or technological advance, the creation of intellectual property rights and commercial interest in the invention.

Mirroring the rise in private industry R&D there has been a dramatic rise in California patent activity. The number of patents granted to California inventors more than doubled between 1980 and 1996, a faster rise than occurred in any other high-tech state (Chart 9). [8] Moreover, these gains occurred from a 1980 level that was already nearly double that of any other state.

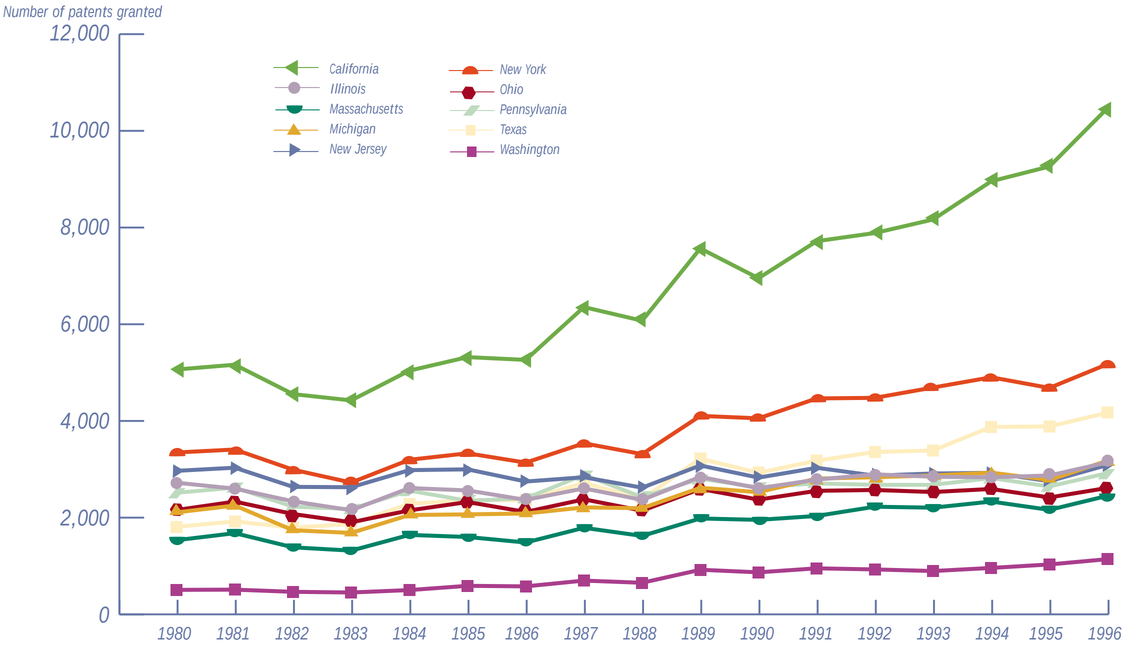
Even on a per capita basis, California patent activity still shows a more favorable growth performance than does that of any other high-tech state. Note in Chart 10 that per capita patents have continued to rise steadily in California, while those of other high-tech states have flattened over the last five (Massachusetts and Michigan) or ten (New York, Connecticut and New Jersey) years. [8] California's per capita patent activity levels are higher than those of all but a handful of high-tech states.

"California dominates in terms of overall patents granted, but not when we take into account its population size. California's patent quality makes it a strong (but not dominating) competitor among the high-tech states."

Lynne G. Zucker & Michael R. Darby
University of California, Los Angeles

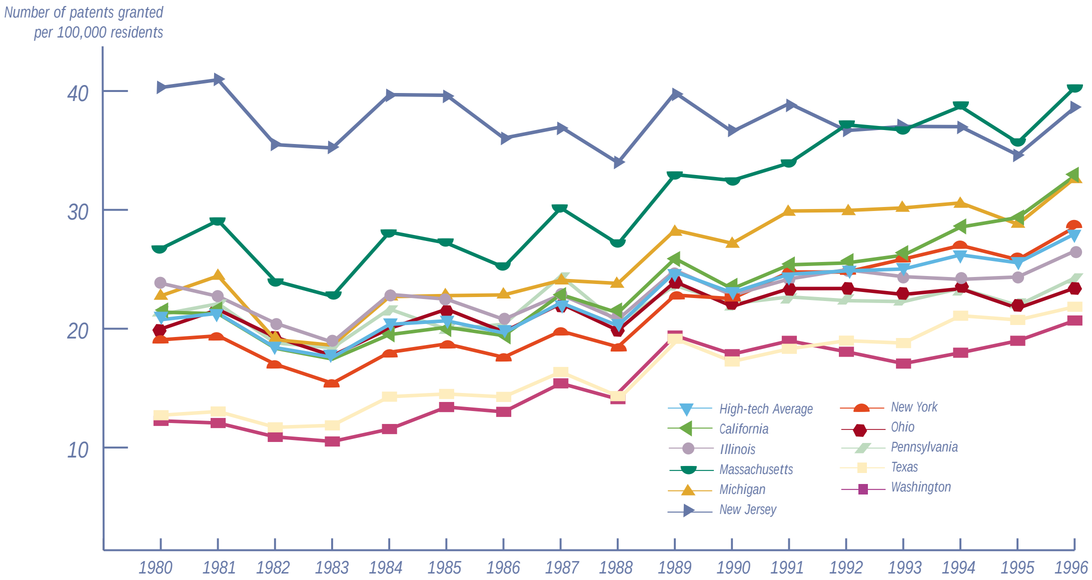
As an indication of the growth in these areas, the number of California patents has grown in the biotech, semiconductor and computer-related industries. Finally, citation rates of California patents (in subsequent patents) are higher than or comparable to those of any other high-tech state, indicating that inventions patented by Californians are high quality.

Chart 9. Patents Granted for High-tech States, 1980-1996



Source: Zucker and Darby [8]

Chart 10. Patents Granted per 100,000 Residents, 1980-1996



Source: Zucker and Darby [8]

Evaluation Of California Patent Activity

Summary: Even on a per capita basis, California patent activity is well above the high-tech state average. Furthermore, per capita activity is growing more rapidly here than in the other high-tech states, especially in emerging fields such as semi conductors, computer-related and biotech. Finally, citation levels for California patents are comparable or superior to those of any other state, indicating the very high quality of California inventions.

Recommendations: State government, industry and academia must sustain and increase R&D investment to keep the pipeline of new inventions open via R&D activity.

V.2.2 PERFORMANCE OF ACADEMIC INSTITUTIONS

We have seen that federal support of California R&D has declined dramatically in the last ten years, that state funding has not kept pace with inflation, and that private support of basic R&D in California is still relatively small. Therefore, it should not be surprising that the volume of research performed by California universities has fallen behind that of other high-tech states. California universities' share of total academic research expenditures has fallen from 13.6% in 1975 to 11.7% in 1995, slightly above California's share of total U.S. employment, but far below our share of high-tech employment.

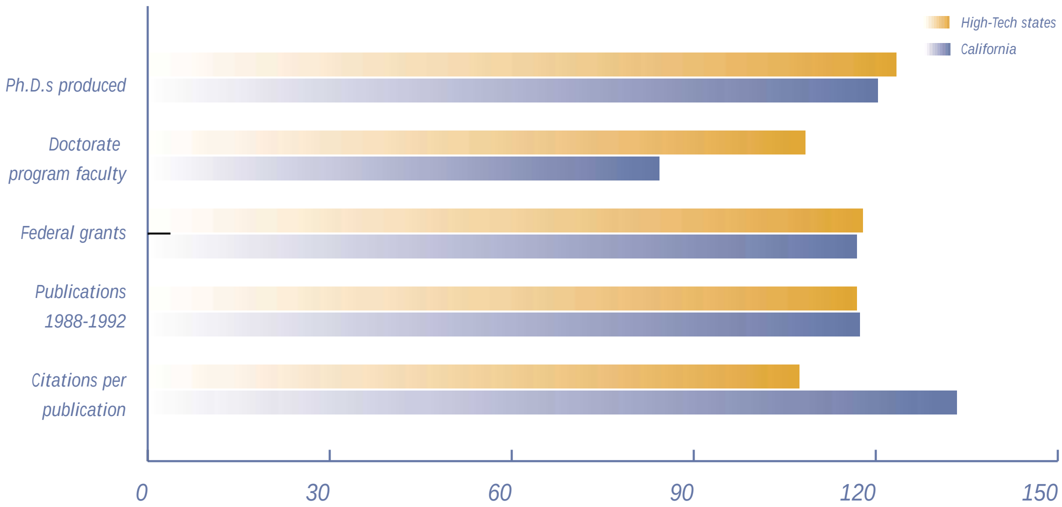
Darby and Zucker's [9] study of academic R&D activity provides more insight into the quality and quantity of research performed by California universities. NSF data on five indicators of academic science: Ph.D.s produced, doctorate faculty size, federal grants received, publications, and citations per publication were examined in detail.

As seen in Chart 11, science and engineering Ph.D.s awarded per capita in California were 120% of the national average, but slightly below the average for other high-tech states. The same was true for federal grants received per capita. The number of doctorate program faculty per capita was less than 85% of the national average for all states and even further below the average for high-tech states. Despite this, the relatively small faculty base at California universities produced a relatively large number of journal-worthy articles. Furthermore, these articles were, on average, very widely cited by other researchers.

However, over the last decade, California has not managed to maintain its relative position. In particular, California has lost important ground to Massachusetts in nearly every area of science and engineering, including the commercially crucial technology fields. In the information technology field, California's top scientists' publishing rate has fallen behind the national per capita average for their peers.

These findings suggest that California is falling behind competing high-tech states in terms of the quantity of inputs into the academic scientific process (faculty and Ph.D. candidates). At the same time, California's academic research was of excellent quality.

Chart 11. California's Science and Engineering Base – All Research Doctorate Programs, 1993 Study

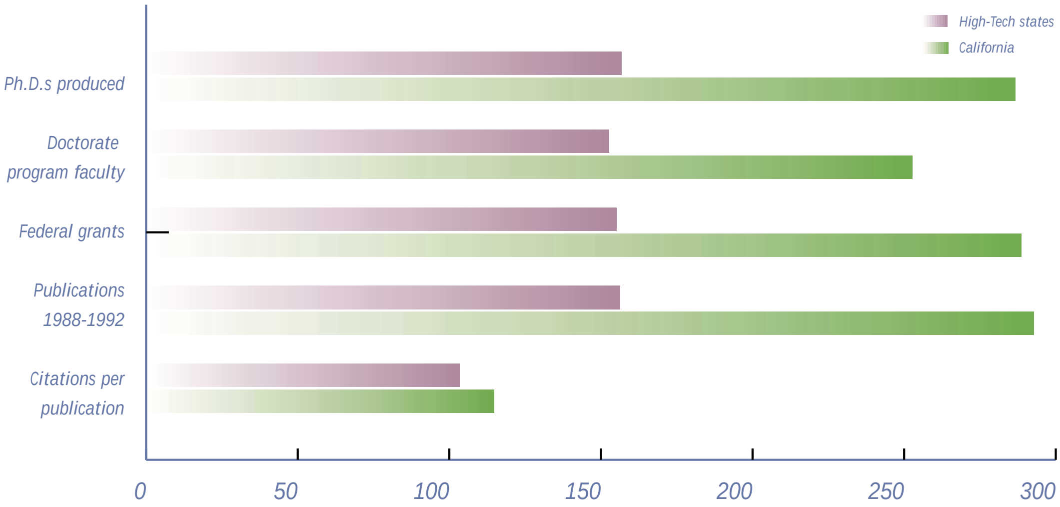


Source: Zucker and Darby [8]

The latter conclusion is further supported by data focusing only on doctoral programs ranked among the top 10 in their field by the National Research Council (NRC) as shown in Chart 12. For top-ten-rated departments only, California ranks far ahead of the high-tech state average for all the academic science indicators, even the ones for which it lagged far behind when all departments were included.

The results clearly indicate that California's science and engineering base is built upon relatively few university faculty members of extraordinary quality. [9] Darby and Zucker argue that it is the top-rated departments and research labs which are most likely to accomplish the break-throughs that lead to cutting-edge commercial products. On these grounds, California's stellar performance within top-ten-ranked departments promises to sustain the state's competitive advantage in S&T development.

Chart 12. California's Science and Engineering Base – Top-ten NCR Ranked Research Doctorate Programs, 1993 Study



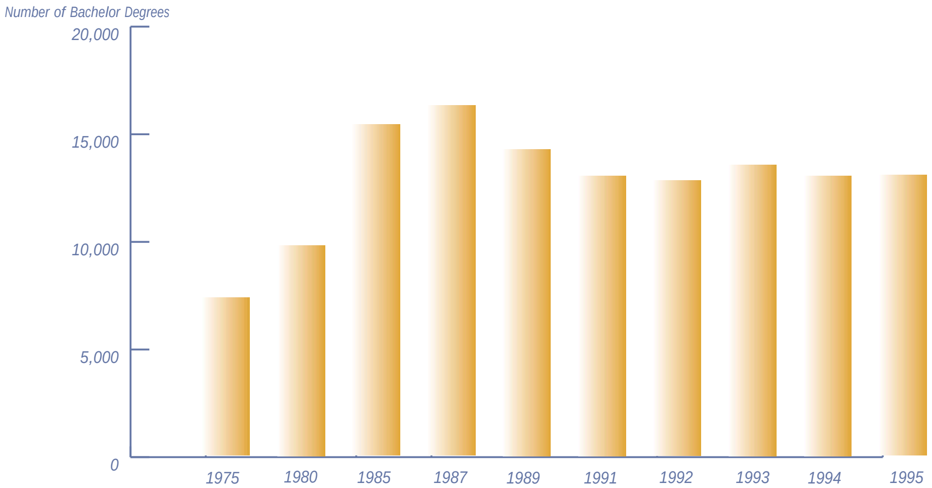
Source: Zucker and Darby [8]

"California's research universities and other scientific base are providing the state a great competitive advantage...But that advantage is slowly eroding, not in absolute terms, but relative to other states which are devoting the resources to build the science base for the next technological revolution."

Michael R. Darby & Lynne G. Zucker
University of California, Los Angeles

The relatively small total volume of academic science and engineering indicates two problems: less university R&D of a more applied nature (normally associated with institutions that do not rank in the top ten) that is useful to industry, and a relatively low output of undergraduates with training in science and engineering (see chart 13). The lower per capita volume of technical R&D at California research universities contributes to lower-than-desirable opportunities for Californians to qualify for production and management jobs in S&T companies.

Chart 13. California Undergraduate Physical Science and Engineering Degrees



Source: Cohen [1]

Evaluation of Academic Institutions' Performance

Summary: California's universities conduct very high-quality scientific and engineering research. However, the size of the state's universities science and engineering departments and the extent of their output have been falling behind other high-tech states. California has lost important ground to Massachusetts in nearly every area of science and engineering, including the commercially crucial technology fields.

Recommendations: State government should improve and sustain higher-education funding levels.

- **Advance policy initiatives and legislation intended to increase funding levels for academic support and R&D activities.**
- **Communicate with the California Congressional Delegation on the importance of sustaining and increasing federal support of the state's R&D activities at universities.**

V.2.3 PERFORMANCE OF K-12

A wide range of surveys and studies finds the state's primary and secondary schools to be under-serving California students, especially those in lower-income areas. In surveys conducted for this study, Calfee [10] finds California employers dissatisfied with workers' skills. Entering workers were found to have poor technical preparation. Even apart from technical skills, it was perceived that entry-level workers lacked the critical-thinking/evaluational and communication skills to effectively perform and advance within the high-tech company's work environment.

Similarly, in the state's public schools, math and science teachers often possess neither a degree nor a minor in the subjects they are assigned to teach. This is especially true for inner-city schools. There must be some correlation between these shortages of teacher skills and the substandard math and science scores California students are receiving on standardized tests. Despite substantial efforts of the CSU and UC teacher education programs, these shortcomings present a critical threat to the ability of all Californians to reap the benefits of the state's economic development.

> ***"Many teachers are teaching out of their subject areas, especially regarding high-tech courses (science and math) and especially in lower socioeconomic regions."***
>
> ***Robert C. Calfee***
> ***University of California, Riverside***

Some private companies are taking their own steps to provide worker-education programs to overcome the shortcomings of the public school system. However, the bulk of the responsibility for dealing with these problems lies with the state government. Proposition 13 and 98 and other state laws have not dealt adequately with the funding aspects of K-12 education. California per pupil expenditures are still below the national average. Also, although California teacher salaries are on par with those in the rest of the country, they are insufficient to attract and retain qualified persons to teaching. Efforts made to remedy class-size problems in public schools have devastated the substitute pool and brought a number of uncertified teachers into California schools. In 1997-1998 11% of California teachers had emergency credentials; however, the magnitude of the problem is greater in the state's urban districts. In 1997-1998 21% of the teachers in the Los Angeles Unified School District had emergency credentials and 15% of the teachers in the Oakland Unified School District had emergency credentials. The rate of supply of certified teachers is far below the need.

The state needs a dual-pronged program that will give K-12 students an adequate grounding in math, science, and technical skills and encourage them to pursue a career in the knowledge-based economy. These two strategies can be accomplished through a variety of avenues, including developing public-private partnerships with industry, creating strategic alliances with educational institutions or foundations, among other creative solutions.

Evaluation of K-12 Education

Summary: Primary and secondary schools in California are not adequately preparing students for the high-tech workplace. This shortcoming is just as critical for students entering the labor force after high school as it is for college graduates. While these failings have not yet seriously impeded development of high-tech industry in California, if not corrected they will prevent Californians from fully capitalizing on future development.

Recommendations: State government should ensure that substantive changes are made at the K-12 level to better prepare students for high-tech careers when they graduate, and that they have the right combination of skills to satisfy employers expectations.

- **Ensure that K-12 students have a solid grounding in math, science and technical skills.**
- **Develop incentives that encourage K-12 students to pursue elementary and high school teaching careers.**
- **Expand teacher education programs in the CSU and UC systems.**
- **Impose reasonable minimum training requirements for public school teachers.**
- **Develop incentives that encourage teachers to pursue multiple subject certification; and minimize out of subject teaching assignments.**

V.2.4 FEDERAL LABS

There are 48 federally funded laboratories in California. [11, 12] Among the largest federal labs in California are Lawrence Berkeley National Laboratory (LBNL), Lawrence Livermore National Laboratory (LLNL) and the Jet Propulsion Laboratory (JPL). All three of these are government-owned, contractor-operated facilities, and all three also qualify as federally funded research and development centers. California's federal labs span a wide array of nondefense areas, from aerospace to agriculture and include some of the nation's top research institutions such as the Stanford Linear Accelerator and The George Brown Salinity Laboratory.

"In carrying out their traditional government missions, federal laboratories are now working with industry in innovative ways to reduce procurement costs, reduce operational costs, and improve laboratory technical capabilities. These new policies create opportunities for California companies."

Patrick H. Windham
Consultant

Their unclassified technologies and expertise are available to the private sector through technology transfer programs. Over the last 20 years, new federal laws have allowed federal laboratories and their contractors to hold effective ownership rights to inventions resulting from their research. These same laws have authorized and encouraged these federal laboratories to share those inventions as well as general lab expertise and facilities with private companies and with state and local governments.

Contractual technology transfer arrangements between federal labs and the private sector—or state and local government—are called Cooperative Research and Development Agreements, or CRADAs. (JPL's authority for technology transfers derives from different federal legislation, and its partnerships are called Technology Cooperation Agreements, or TCAs.) Federal funding for CRADA/TCA arrangements is extremely limited. The usefulness of these facilities to private-sector companies is also limited by security provisions at the federal labs and by potential political hazards to the labs from these operations. However, federal laboratories do welcome industry-funded cooperative research projects, and the number of such industry-funded CRADAs has increased in California in recent years. These projects give California companies access to valuable federally funded researchers and technology. Private companies may also use valuable unclassified research equipment at the laboratories, another benefit to California industry.

Notwithstanding these limitations, state agencies could take greater advantage of these facilities. Many of the federal labs—and all the larger ones—have advanced expertise in computer programming and systems design. This expertise is usually not subject to security provisions and could prove especially useful to state and local government agencies.

The problem is that state and local agencies do not always possess the in-house expertise or R&D funds to work effectively with experts at federal labs. There have been some notable examples of successful collaborations, such as LLNL work to help the State Water Resources Control Board and California Environmental Protection Agency to monitor groundwater contaminants. In other cases, though, federal labs in the state have found it difficult to work with state and local agencies.

The successes demonstrate that the labs have technical expertise that can help state and local agencies. In order to tap further into this expertise, the state should consider which areas the labs can help solve important state problems and then, as appropriate, provide the contracting flexibility and in-house expertise to take advantage of these opportunities.

Besides CRADAs, federal labs are also able to license use of their non-classified intellectual property to private-sector licensees. Again, federal law has enabled the labs to retain any such royalties that arise from licenses, and the labs are also free to license use of technology without royalty payments.

In virtually all respects, the federal labs function as an industry of their own. They employ a large number of Californians. Salary levels are generally commensurate with those at knowledge-based occupations in the private-sector. Furthermore, the labs do interact with private companies and with academia much as private sector firms do, and the spin-offs from discoveries made at the labs have the same types of downstream stimulative effects on the economy as do those in private industry.

From this perspective, the federal labs are functioning as well as can be expected. There is little that the state government can do to expand the scope or budget of these facilities, other than occasionally providing more active support for major new projects, such as the expanded linear collider project that Stanford Linear Accelerator is currently vying for. Similarly, the limitations that private companies face in partnering with the federal labs arise from federal regulations and politics, and these are not an issue for state policy. An obvious policy action that the state government can pursue is to improve its own capability for capitalizing on the federal labs' expertise and on their mandate for sharing technology.

Similarly, on the defense and general federal procurement side, federal budget totals are beyond the influence of state government. However, the state government can take steps to remind the federal government of the debilitating effects on California of 1990s' cuts, to offset the "Anywhere But California" syndrome, and to secure a fair share for California companies of possible future expansion of federal procurements.

Evaluation Of Federal Labs

Summary There is an exceptionally large, diverse set of federal labs operating in California. These labs boast a wide range of expertise, and federal law encourages the labs to share their discoveries and advances with private and public institutions. Any limitations on access to this expertise are common to labs across the country and so are not California-specific issues.

Recommendations: While the state currently under-utilizes federal labs in California, it has the opportunity to promote their use by both the public and private sectors.

- **Expand state government's ability to access the expertise at federal labs. Initiate an effort to determine in which areas the state's labs can help solve important state problems, then provide the contracting flexibility and in-house expertise to take advantage of these opportunities.**
- **Implement a statewide communications and outreach program to make California companies aware of the lab resources available to them.**

So far, the strengths and weaknesses of S&T activity within the private-sector, state, local and federal governments, and university and colleges have been discussed more or less in isolation. However, it is clear that weaknesses in one sector can be offset by strengths in another and that strengths in different sectors can interact. It makes sense, then, to provide another overview to our findings. This section examines the S&T process from the beginning to middle to final stages of the discovery and commercialization process.

Technological products and processes begin with a scientist's or engineer's idea. The researcher performs basic research to determine whether the idea conforms with and expands our understanding of the principles of science, and subsequent researchers perform applied research to determine applications of the idea. Success at these early stages leads to companies' development of commercial products, the middle stages of the process. In the final stages, with marketable products in hand, companies streamline their management operations, structure their work force and establish financing arrangements for ongoing operations.

At all stages of this process, expertise and funding are required, and at all stages, entrepreneurs and companies interact with local, state, and federal government regulations and agencies. Of course, the varieties of expertise, funding, and interaction vary and evolve along the way. Although a great simplification, Table 10 describes aspects of each stage of the process of commercializing technological advance, along with an evaluation of the overall performance of each phase.

Table 10. An Overview of the Innovation/Commercialization Process

Level of Process	Early: A Good Idea?	Middle: A Good Product?	Final: A Good Market?
Applicable level of R&D	Basic Research Applied Research	Development Commercialization	Mass -Production Capitalization Marketing
Relevant Indicators	R&D Expenditures Advanced Degrees Publications/Citations NAS Fellowships R& D Tax Credits Claimed Foundation Grants	R&D Expenditures Patents CRADA Volumes Incorporations Strategic Partnerships Early-Stage VC Flows BS Degrees	Job Growth Late-Stage VC Flows Capital Market Issues/Performance K-12 Science Scores
Funding Sources	Government Grants Foundation Grants Angel Funds	Venture Capitalists Strategic Partners Industrial Investment	Investment Bankers Commercial Bankers Venture Capitalists Strategic Partners
Evaluation of California status	<u>Strengths</u> World Class Universities, Academics Large Number of World-Class Federal Labs <u>Weaknesses</u> "Low" Volume of University Output	<u>Strengths</u> Very Strong Patent Activity Very High Total R&D Unrivaled Access to VC Funds Industrial Critical Mass <u>Weaknesses</u> No Strategy to state R&D, FFRDC-utilization efforts	<u>Strengths</u> Rapid Industrial Growth Industry Critical Mass Access to Capital Markets <u>Weaknesses</u> Skills of Eligible Workers Poor K-12 Performance
Needed Action	Integrate & Focus State Efforts	Few Complaints	Improve Workers' Skills

Status of the Early Stage The findings presented in this report suggest a successful level of early-stage R&D activity in California. However, there are strong and weak areas that counter-balance each other. For example, private-sector companies have greatly increased their scientific investigation in the last decade, and federal labs in California continue to perform an impressive volume of science and engineering despite federal cuts. The research performed by California universities has been found to be of exceptionally high quality. However, there are concerns about the quantity of research performed by California universities which has been declining relative to other high tech states. Foundation support of science is too low. State-supported R&D needs focus and direction agreed upon by lawmakers and R&D performers, and the quantity of California's academic research is smaller than is desirable. However, none of these shortcomings have to date prevented California from performing a much greater-than-proportionate share of nationwide R&D. Also, the sub-standard performance of California primary and secondary schools is not yet apparent in this process.

All in all, the relevant indicators suggest a favorable, but slipping, California performance at this stage of the S&T development process. The great strengths here more than outweigh whatever weaknesses exist.

Status of the Middle Stage Both the state's R&D activity and the volume and quality of patents awarded to California inventors indicate a favorable performance in the middle stages as well. The presence of California federal labs technology partnerships and their capacity—though limited—for technology partnerships with private and public operations figure here as well. Similarly, California companies have been found to have unparalleled access to venture capital funds, which are vitally important at this stage. Finally, the S&T industry growth already seen in California provides the critical mass that will encourage further advances at these levels in the future.

The weaknesses apparent in these middle stages of California's S&T performance relate to the drag incurred from the lack of focus on state government R&D policies. Although the relevant indicators suggest that the weaknesses at this stage are somewhat compensated for by the strong performance of California private companies and federal labs, this is an issue of concern.

Status of the Final Stage At this stage, the most relevant indicators are the "pay-offs." Are past discoveries and advances turning into present jobs for California workers and successful performances for California companies? The employment data in Section II indicate that California high-tech industries are growing rapidly and are generally holding or increasing their shares of national employment in these sectors. Keep in mind that the job data indicate levels of workers employed in California, not total employment of California companies. So the data show the ability of companies to compete successfully using California facilities and workers.

Similarly, "late-stage" venture capital fundings in California are growing as fast as or faster than nationwide. The venture capital funding trends indicate that more fledgling California companies are recognized as economically viable by capital markets.

The troublesome issues here concern the future viability of the California labor force. As argued in Section V.1.6, there is probably not a present skilled labor shortage per se. However, the performance of California K-12 schools does give cause for concern as to whether sufficient, adequately trained supplies of California workers will be available to S&T companies in the future. Again, this may not impede California companies' future growth. Skilled labor can be imported, and additional facilities can also be located outside the state. However, if technology companies must increasingly resort to non-California skilled labor, this will necessarily divert the incomes and benefits associated with those jobs away from California constituents.

The attention paid to the H1-B visa program for immigrant workers hints at possible problems in the future. The H1-B program has not accounted for a large fraction of high-tech employment growth either in California or the U.S. as a whole. However, these needs could become more important in the future. Even at present levels, the importation of skilled immigrant labor represents lucrative occupations and opportunities for which California workers may have been unable to effectively compete.

All in all, California's performance in the final stages of S&T commercialization appears adequate, but concerted actions should be taken to sustain this performance and to improve it.

Is California Unattractive? In discussing the weaknesses of California's S&T infrastructure, congestion or cost-of-living issues have not been mentioned. These were omitted partly because they pertain to all industries, not just to high-tech industries, but mainly because it can be argued that these are in fact symptoms of a continuing, intense demand for and attractiveness of the California lifestyle.

As an analogy, should a high price for a product be considered a deterrence to its attractiveness or an indication of exceptionally high demand for the product, or both? A much demanded product will tend to be relatively expensive. The higher price for it is the most efficient way to "ration" demand to those for whom it is most valuable.

California home prices have risen far above those in the rest of the country only since 1960 (when they were just 110% of the U.S. average). This has occurred as available suburban land began to disappear and as California rose in the national consciousness as an attractive place to live. California population has continued to grow rapidly over that period, even as the state became an increasingly high-cost location. Furthermore, only during recessions have the state's high cost of living and congestion (a non-monetary "cost" of living) served to induce "out-flight" by firms and households.

These facts indicate that living costs and crowding are indeed a symptom of the continuing attractiveness of the state. "Luxury" products draw more affluent customers who can better afford the higher cost and will "crowd out" less affluent buyers. Similarly, the state's attractions are a lure to higher-income companies and workers.

This doesn't mean that state policy makers can ignore the burdens of congestion and the side effects of higher living costs. In fact, it makes it all the more incumbent on California policy makers to prevent regulatory and tax burdens from unnecessarily adding to the "costs" of California. These factors make it even more crucial for the state's educational system to train native Californians for high-tech jobs, so employers don't have to hire better-trained immigrants.

Overall Conditions Are Satisfactory, But There Is Substantial Room For Improvement All things considered, the state's science and technology sectors are performing well. Early- and middle-stage high-tech development is outstanding, and California companies are at the least holding their own in the final stages of competition in product and labor markets.

Similarly, private-sector performance was found to be superior, as was that of the federal-government sectors operating in the state. The quality of the state's higher-education system was found to be outstanding. The shortcomings found were in the areas of corporate support of academic and early-stage research, in K-12 school performance, in the ability of California's higher-education institutions to meet the needs of future industry growth, and in the inadequate utilization and direction of the state government of the policy tools available to it.

California entrepreneurs and managers have done a commendable job in this decade of restructuring the state's economy away from a defense/aerospace focus to a private-sector/knowledge base. The tools are being developed which will allow the state to extend these gains well into the next century. To ensure that this continued progress will be made, private companies need to provide more active public leadership, and state officials need to implement policy actions to insure that growth continues.

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APPENDIX A

PROJECT SUMMARIES

An evaluation of California science and technology indicators by Linda R. Cohen [1]. Cohen examined R&D expenditures within the U.S. and California, as well as data on patent activity and other science indicators. California scientists perform an exceptionally large share of U.S. R&D and receive a disproportionately large share of U.S. patents. Within the last ten years, the composition of California R&D activity has changed immensely, as private-sector companies have dramatically increased their outlays, more than offsetting sharp declines in federal activity related to post-Cold War budget cuts.

An analysis of state-supported R&D in California by Jeffrey I. Chapman and Victoria Koehler Jones [2, 3]. Koehler Jones has constructed a detailed, consistent time-series database of R&D activity supported by the state government. Chapman's analysis of this database finds state-supported research to be diffusely distributed. He finds insufficient strategy or structure behind this research effort. Finally, their research shows that state-supported R&D levels have been flat since 1995 and ranks California 32nd in the nation for total state R&D support per capita.

An analysis of California's R&D Tax Credit by Bronwyn H. Hall [4]. California provides an income tax credit on incremental R&D expenditures, supplementing the federal credit. Hall finds this credit to be a small but rapidly growing component of California fiscal policy. The credit is of limited use to small, start-up companies/inventors, because its record-keeping requirements are especially burdensome to new companies and because new firms often don't have income-tax liabilities against which to charge the credits.

An analysis of venture capital funding activity within California by Michael T.K. Horvath [5]. Horvath finds that California is the venture capital leader of the U.S., mainly because computer and biotechnology companies based in the state are attracting large amounts of venture capital from firms within and outside of the state. This large, diverse and thriving venture capital sector is good news for California's economy. Venture capital to California companies continues to grow in all S&T areas.

An examination of private foundation support of scientific study in California by Sandra A. Glass [6]. Charitable foundations can be active beneficiaries of scientific research. However, Glass finds despite significant increases in foundation assets, their grants to science and engineering have been stagnant over the last few years. Also, the evidence suggests that California beneficiaries have received less-than-proportionate shares of science grants activity.

An evaluation of the adequacy of the supply of skilled laborers to California technology industries by Robert C. Calfee and Cecilia A. Conrad [7, 10]. Calfee examines the performance of California primary and secondary schools in preparing students for participation in the high-tech marketplace. Conrad analyzes the performance of the California high-tech labor market itself. Calfee finds that K-12 math and science teachers are often under-qualified. California students are under-performing, not only in technical areas, but also in the basic critical-thinking and communications areas required for success in the S&T workplace. Conrad finds reason to dispute the contention that there is a "shortage" of skilled workers per se. However, there is cause for concern that insufficient training/background will prevent Californians from enjoying their full share of the benefits of the S&T economy.

An evaluation of the intensity of scientific investigation and training by academic institutions and of the details of patent activity by Lynne G. Zucker and Michael R. Darby [8, 9]. Darby-Zucker find California academe science base is built upon relatively few university faculty members of extraordinary quality. While the quality of California academe is an asset that should be preserved, the declining volume of this output relative to that of other high-tech states is a potential problem. Meanwhile, California inventors receive a disproportionately large share of national patent activity, and these patents receive an especially large volume of citations in subsequent patent applications, indicating California inventions are of high quality.

A survey of federal laboratories in California by Patrick H. Windham [11, 12]. Windham finds California to possess an exceptionally large number of federal labs with an extraordinarily wide range of operations. These labs are nominally encouraged to share technology with the private and public sectors, but political and security considerations limit the practical application of these partnerships. Still, the labs provide a valuable asset to California's high-tech economy.

APPENDIX B

LIST OF PRINCIPAL INVESTIGATORS

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Patrick H. Windham, Consultant
Lynne G. Zucker, Professor of Sociology and Policy Studies, University of California, Los Angeles

APPENDIX C

GLOSSARY OF TERMS

Angel Investors: These are outside investors, often with considerable wealth, investing their own funds in return for equity positions in companies. Angels may invest alone or in loosely organized groups or "bands." They may take positions on the board of directors or provide advice to management. Angel investments typically occur prior to venture capital investments, at the earliest stages of a start-up company's development. The biggest distinguishing feature between angel investors and venture capital investors is that angels invest their own funds while venture capitalists invest the funds of their limited partnership, a majority of which come from the limited partners who do not make the investment decisions.

Federal labs: Federal laboratories can be separated into those that conduct R&D or those whose sole purpose is to test or analyze samples for chemical, physical, or biological properties. This report uses the term federal labs to refer to those labs performing R&D. About 515 of the approximately 700 federal labs across the U.S. are research and development labs.

Federally Funded Research and Development Centers (FFRDCs): FFRDCs are organizations operated by contractors and performing research for the federal government and they operate under special FFRDC contracting rules.

Gross Domestic Product of the U.S. (GDP): GDP consists of all market-based economic production and services occurring within the territorial limits of the United States. Not all components of GDP involve money outlays. For example, GDP includes imputations for the "market value" of shelter services received by resident homeowners from the usage of their home. GDP includes the income and profits of foreign citizens and corporations earned while residing in the United States. It does not include income or profits of U.S. citizens and corporations earned from foreign operations (or while in residence abroad).

Gross State Product (GSP): GSP is a concept intended to be equivalent to Gross Domestic Product, but on a state level. Thus, it includes the value of all market-based production and services occurring within a state's borders.

High Tech: In this report, the terms "high tech" and "science and technology" are used synonymously. The terms are used to denote academic departments, industry groups, and occupations that involve intensive usage of scientific knowledge. Almost always in this study, the "science" referred to includes physical sciences and engineering. That is, social science, health sciences, and environmental – alternatively, ecological sciences – are typically not included in this term. The American Electronics Association (AEA) definition of high tech focuses on computer technology and programming, electronic communications, avionics, and other electronic instruments. This study defines high-tech to include aerospace, biotech, and multimedia in addition to the AEA group.

High-Tech States: A number of studies in the CREST report focus on the performance of "high-tech states." These are states for which high-tech industries, as defined above, constitute a relatively large portion of total employment and production and for which state policies and higher-education facilities have specialized in academic research in science and technology fields. High-tech states used in this study include California, Illinois, Massachusetts, Michigan, New Jersey, New York, Ohio, Pennsylvania, Texas, and Washington.

Start-Up Company: A start-up company is one in the earliest stages of development. Company operations will typically be more involved in product development than in production or marketing. Revenues and profits will typically be small or negligible relative to operating budget. For all these reasons, access of the company to formal commercial bank or investment bank finance will be limited or non-existent, in which case venture capital funding is often a major source of company financing. While these defining characteristics are not precise, need for external financing is likely the most telling and most common characteristic of "start-up companies."

Science and Technology: See "High Tech."

Venture Capital: Equity capital invested in innovative and/or rapidly expanding enterprises, typically prior to a public stock offering.

Venture Capitalists: Professional private equity fund managers. Their role is to identify and invest the venture capital partnership's funds in innovative and/or rapidly expanding enterprises in need of external financing in return for equity. They are also responsible for monitoring their investments which often involves taking board seats at their investee companies. They raise their partnerships funds used in this way by soliciting limited partners with long time-horizons: wealthy individuals, organizations with large endowments, and/or insurance companies. Typically, less than 10% of a venture capital fund's assets come directly from the fund's principle venture capitalists and over 90% come from the limited partners who make no investment decisions.

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