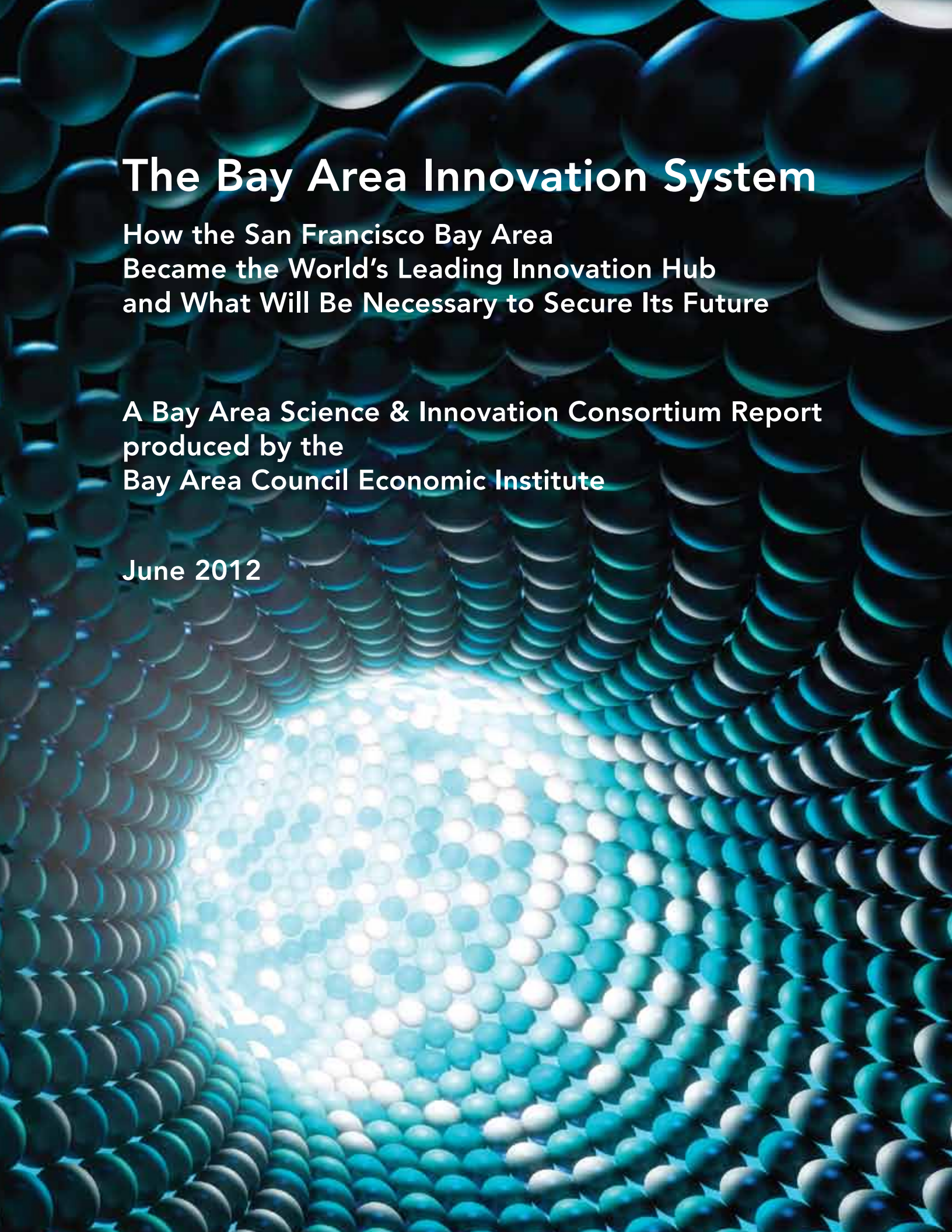

The Bay Area Innovation System

How the San Francisco Bay Area Became the World's Leading Innovation Hub and What Will Be Necessary to Secure Its Future

A Bay Area Science & Innovation Consortium Report
produced by the
Bay Area Council Economic Institute

June 2012

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BAY AREA COUNCIL
BASIC
BAY AREA SCIENCE & INNOVATION CONSORTIUM

Message from the BASIC Chairman

For more than 50 years, the Bay Area has been a leading center for science and innovation and a global marketplace for the exchange of ideas, delivering extraordinary value for California, the nation and the world. Its success has been based on a unique confluence of research institutions, corporations, finance and people, in a culture that is open to the sharing of new ideas and willing to take significant risk to achieve extraordinary reward. The Bay Area innovation system is also highly integrated, with components that closely interact with and depend upon each other.

The Bay Area Science and Innovation Consortium (BASIC), a partnership of the Bay Area's leading public and private research organizations, has prepared this report to illustrate how the Bay Area's innovation system works and to identify the issues that may impact its future success. Ensuring that success will require partnership between the public and private sectors, continued investment in the region's core assets, and attention by state and federal policy makers.

Mark Bregman
Senior Vice President and CTO, Neustar, Inc.
Chairman, BASIC

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Executive Summary

The Bay Area has been the world's leading innovation center for the past 60 years. Its impact on the economy and how it operates, from enterprise productivity to health and communications, has been immense. The region's ability to play a role in the creation of entirely new business paradigms and spaces of social activity—including personal computers and smart phones, semiconductors, cleantech, biotechnology and personalized medicine, relational databases, magnetic storage and most recently cloud computing—is unrivaled, producing world-leading companies and jobs in the Bay Area, nationally and around the world on a large scale. It has also impacted the lives of hundreds of millions of people who use and benefit from the technology and services it generates.

The region's ability to conceive, research, develop and commercialize new technologies and business models is based on an interconnected innovation system composed of a diverse set of institutions and actors that are linked by networks and share distinct cultural perspectives on how value is created. Together, these components and processes constitute an innovation value chain that—because innovation is dynamic and often non-linear—can also be described as an innovation cloud. This system has proven resilient, reinventing and repurposing itself through multiple crises and economic cycles.

The Bay Area innovation system is built on a core of key institutions. The most critical are associated with higher education: leading research universities—the four regional campuses of the University of California and Stanford and supporting institutions—as well as the region's five California State University campuses and its 26 California Community Colleges.

The research universities are a major source of patents and inventions that are licensed to private companies—to date the region's four UC campuses have generated nearly 1,800 patents and 3,000 active inventions—and they generate graduates and faculty with an extraordinary track record of taking ideas and technologies from the laboratory bench to commercial applications. The companies they have created rank among the best known and most successful in the world, with hundreds of thousands of employees in the Bay Area, the U.S. and globally. Examples include Genentech, Chiron (since acquired by Novartis), Agilent Technologies, Cisco Systems, Dolby Laboratories, Apple, eBay, Google, Hewlett-Packard, LinkedIn, Netflix, Sun Microsystems (since acquired by Oracle), Tesla Motors, Varian and Yahoo!—to name only a few. The universities also provide common ground where competitors from industry can interact with academic investigators and with each other for open exchanges on shared research questions.

The California State University system, private universities and the California Community Colleges provide critical support at another level, through the tens of thousands of bachelor's and master's level engineers and trained technical staff who populate the Bay Area and Silicon Valley workforce. San Jose State University, for example, has the region's largest engineering program, with approximately 4,700 students. The Foothill-DeAnza Community College District educates approximately 70,000 students per year, many of whom are employed in Silicon Valley, and is the community college system's top feeder to the University of California and San Jose State.

Federal laboratories are another core component. These include four U.S. Department of Energy labs—Lawrence Berkeley, Lawrence Livermore, Sandia (California), and the Stanford Linear Accelerator—as well as NASA's Ames Research Center, the San Francisco Veterans Administration Medical Center, the Veterans Administration Palo Alto Health Care System, and the Joint Genome Institute (a collaboration of Lawrence Berkeley with Lawrence Livermore).

Built on this infrastructure of research facilities is another layer of unique institutions that are multi-disciplinary, multi-partner collaborations: the Joint BioEnergy Institute (which includes Lawrence Berkeley, Sandia, Lawrence Livermore, UC Berkeley and UC Davis), and two California Institutes for Science and Innovation—QB3 (the California Institute for Quantitative Biosciences which links UC San Francisco, UC Berkeley and UC Santa Cruz), and CITRIS (the Center for Information Technology Research in the Interest of Society which links UC Berkeley, UC Davis, UC Santa Cruz, and UC Merced).

Intertwined with this network of state and federal institutions and facilities is a large Bay Area community of independent and corporate labs, some of which conduct basic (deep) research, but most of which focus principally on applied research. Like the universities and federal laboratories, their fields of inquiry span a range of disciplines and sectors from information and communications technology (ICT) to life sciences. The most prominent of these include Hewlett-Packard, Agilent, SRI International, Kaiser, PARC, Intel, Genentech, the Gladstone Institutes and the Buck Institute for Research on Aging. A large number of nationally and globally headquartered companies also operate R&D facilities in the region. This notably includes IBM, GE, Microsoft, Lockheed Martin, Pfizer, Bayer, Merck, Huawei, Novartis and SAP. Many U.S. and foreign auto companies have labs in the region that tap into the latest innovations in information technology for potential automotive applications.

These educational institutions, research laboratories and research-based companies have close collaborative relationships, as illustrated in the diagram on page 50. Corporate and independent labs in particular conduct joint research with universities and federal labs, facilitating the creation of new knowledge and the translation of basic science into commercial applications.

The commercialization process is also advanced through a highly developed system of incubators and accelerators, which are supported by local governments, foreign governments, universities, corporations, or federal laboratories, or may be independent. At least 80 of these facilities operate in the region, providing flexible office space, networking opportunities, legal and consulting advice, and access to venture capital for thousands of start-up companies.

The process of commercializing innovation is fueled by a deep reservoir of venture capital, angel investment and private equity that finances start-up and early- and later-stage companies in a range of sectors. More than 300 venture capital and private equity firms that invest in emerging companies operate in the region. The concentration of venture capital in the Bay Area is unique and draws young companies to the region from throughout the U.S. and around the world. Despite its small geography, the Bay Area on average attracts 36% of all venture investment in the U.S. and 16% of global venture investment. In recent years this number has trended upward: in the fourth quarter of 2011 the region attracted 46% of national venture capital investment.

Key to how the region innovates is not just its moving parts but their pattern of interaction. Technology businesses are supported by a deep infrastructure of legal, financial, accounting and other service providers with specialized knowledge on start-ups, intellectual property, and technology. Formal and informal networks provide settings and environments where businesses and entrepreneurs can share ideas and experience. Experienced mentors provide advice and support for start-ups, and successful business leaders become serial entrepreneurs and venture capitalists, supporting new generations of young companies.

Harder to quantify is a business culture that encourages risk-taking and accepts failure—an environment that supports entrepreneurial activity. Perhaps the most important binding factor, however, is the region's openness to new ideas and new participants. Multiple disciplines collide and interact, creating novel ideas and unanticipated applications (where, for example, information technology meets life sciences to create bio-informatics). This is enabled by a culture that is highly permeable, with few institutional barriers to the movement and combining of people and ideas.

The economic benefits generated by this system have been substantial, not just for the region, but for the national and global economies. The Bay Area is home to more U.S. Fortune 500 and Global Fortune 500 companies than anywhere except New York, and it is home to more of the fastest growing companies than anywhere in the nation. By a dramatic margin, it produces more total patents (16,364 in 2010) and more patents per million inhabitants

(2,651 in 2010) than anywhere in the country, as well as the nation's highest share of patents (15.2%). This is reflected in a number of emerging sectors. Nearly half of the top 100 private cleantech companies and 7 out of the top 10 social media companies are located in the region.

While there is good reason to believe that this system will remain resilient and continue to generate economic benefits for the foreseeable future, it is challenged from several directions. Increasingly, research capacity is less concentrated and more distributed, as other countries increase their investment in research and education and pursue their own strategies to become technology and innovation centers. This is particularly the case in Asia. While it remains to be seen whether these government-driven innovation efforts can produce the deep research or game-changing innovation of the type seen in the Bay Area, there is little doubt that this investment in research and education will increase their competitiveness and will create areas of strength in applied research and commercial applications. When this capacity for applied research is combined with growing strength in manufacturing, the shift of R&D to globally distributed innovation centers will accelerate.

This growth of research and innovation capacity in other countries isn't necessarily a bad thing for the Bay Area. Specialized research capacity and pools of talent around the world create opportunities to combine and leverage diverse capabilities. As those benefits are distributed and reflected in economic growth, new opportunities are created for U.S. and Bay Area companies. This pattern is already embedded in the globally distributed research activity conducted by Bay Area and other companies. Some, such as Hewlett-Packard and IBM, maintain extensive networks of global laboratories. Others collaborate closely with investigators and institutions in other countries. Many contract with overseas partners for specific kinds of research or, in the case of biotech, for services such as clinical trials.

The Bay Area occupies an advantaged position in this global process, through its strength in basic research, the global reach of its companies, its openness to participants from outside the region, and its success in translating ideas into products through entrepreneurial activity and venture finance. Due to these attributes, the Bay Area has evolved from being a stand-alone research and commercialization center to being a global innovation super-hub, leading in many fields but also serving as a collaborator and integrator for a range of global partners.

This leadership role is not guaranteed, however. The global system within which the Bay Area operates is dynamic, and to remain the world's leading center for business and technology innovation, the Bay Area—with California and the U.S.—must continue to invest in its core assets. Here, the region faces challenges on several levels.

At the federal level, constrained budgets are impacting R&D investment. While the United States retains its dominant position in total dollars spent, in recent years government R&D investment has stagnated. At the moment, research funding appears stable but, given recent budget trends, is vulnerable. Seeing the need to diversify their activity and sources of support, federal labs are working to expand cooperation with surrounding communities and the private sector through incubators, joint research and technology licensing. This transition will require sustained focus and support in Washington. Abrupt budget cuts or consolidation could have negative economic and security implications.

At the state level, public higher education has seen a dramatic drop in financial support. This is a critical issue, as 90% of higher education in the state is provided by public institutions. At UC, the state now contributes 60% less to student education than it did in 1990 (in inflation-adjusted dollars). The university has responded with measures including higher student fees, fewer classes, salary reductions, and expanding the number of out-of-state students (who, in contrast to in-state students, pay full tuition). But after years of reductions, each new wave of cutbacks cuts closer to the bone of the university's core educational mission.

CSU confronts similar issues, as state support has fallen almost 40% since 2007–2008, from just under $3 billion to roughly $2 billion. Fee increases have generated close to $600 million in new revenues, leaving a deficit of more than $500 million in resources for instruction, student services and operations. The effects are likely to be seen in reduced library acquisitions, deferred maintenance, program eliminations, workforce reductions and lower enrollment.

These challenges tier down to the Community Colleges level, where per-student funding is lower than it was in 1994–1995, and cutbacks are evoking a similar set of responses: course reductions, administrative consolidation, fewer student services and, in the end, fewer students. In 2009–2010, 140,000 potential students were turned away due to lack of funding.

Another issue that particularly affects the region's innovation system is immigration and the constrained availability of visas and green cards for skilled workers and highly educated graduates of U.S. universities. This is significant, as California's educational system is increasingly failing to produce the graduates the state needs to support a skilled and globally competitive workforce, and as foreign graduates of U.S. universities are enticed back to their home countries by growing opportunities and government incentives. Educated immigrants heavily populate the region's research laboratories and the science, technology, engineering and mathematics

departments of its universities and are responsible for many of these institutions' major innovations. A top scientist can generate $30–100 million in direct and indirect value over the course of his or her career. Immigrants have also demonstrated a high propensity for entrepreneurship, founding many of Silicon Valley's and the Bay Area's iconic companies. In the U.S., 25% of start-ups have at least one immigrant founder; in Silicon Valley the number is 52%.

Many young companies lack access to capital. Despite the continued vitality of the region's venture capital system, the number of deals, the amount invested and the number of IPOs all remain well below their historic peaks, and investors have increasingly shifted their focus from start-ups and early-stage to later-stage companies. Some observers also note a shift of investor interest from long-term plays that require significant technology R&D to short-term investments with quicker payouts in fields such a social media.

The Bay Area's innovation system is impacted by all these trends, both positive and negative. Its flexibility and openness, its global connectivity, the depth and diversity of its technology domains, and its success in translating research and ideas into commercial value are not easily replicated. Because of this, for the foreseeable future the Bay Area is likely to remain an innovation super-hub and the world's leading marketplace for ideas.

Its success can be traced to the depth and diversity of its research capacity and the fluidity with which its actors interact. It is an integrated, interdependent system where the whole is greater than the sum of its parts. Because of this, damage to the integrity of any major component of the system can impact the operation and effectiveness of the system as a whole.

To ensure that the Bay Area's innovation system will continue generating economic and social benefits for the region, its partners and the nation, measures should be considered at several levels, including:

- Sustained and strengthened support for public higher education at all levels (UC, CSU and Community Colleges).
- Policy support for educational innovation, to enable universities and colleges to be more entrepreneurial in how they engage with business to generate revenue and create value.
- Sustained or increased support at the federal level for basic research.
- Attention to federal export control policies that unnecessarily inhibit research.
- Improved intellectual property management processes at universities and federal labs, to lower barriers to research and technology transfer between universities, national laboratories and industry.

- The development of consortia and hybrid research models to enable closer collaboration between national labs, universities, industry and investors.
- Strategies to enable process innovation and advanced manufacturing.
- Immigration reform to assure continued access to the best global talent through greater access to H-1B and other visas and green cards for students graduating from U.S. universities with advanced science, technology, engineering and mathematics degrees.


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Introduction

The Bay Area economy has been the world's premier innovation center for the past 60 years. It has had immense impact on key sectors and how they operate—from enterprise productivity to communications and media—as well as on the lives of individuals throughout the world. The nine-county Bay Area, if seen as a country, would be the 19th largest economy in the world with a GDP of $533 billion. The region's ability to play a significant part in the creation of entirely new business paradigms and spaces of economic and social activity—from personal computers to smart phones and mobility, and from semiconductors to cleantech, biotech, personalized medicine, relational databases, magnetic storage and most recently cloud computing—has been unrivaled. This has produced world-leading companies and jobs on a large scale. It has also impacted the lives of hundreds of millions of people who use and benefit from its technologies, therapies and innovations.

Recognizing this success, many regions around the world have attempted to replicate the Bay Area's accomplishment, as seen in the large number of "Silicon" copies—Silicon Valley North, Silicon Fen, Silicon Wadi, Silicon Alley, etc. While most have attempted to distill and reapply the region's recipe, none has yet succeeded at fully recreating it. As a result, the Bay Area's system has remained unique and its ability to drive the U.S. technology economy unquestioned—until recently.

> *"Innovation has become the new currency of global competition as one country after another races toward a new high ground where the capacity for innovation is viewed as a hallmark of national success."*[1]
> — *John Kao*
> *Author, Innovation Nation*

Over the course of the past 7–8 years, the Bay Area's innovation system has come under growing pressure from a variety of factors and forces. Some of these are global, some are national and some are local and homemade. Some of these challenges are political and some economic. All of them in concert are challenging the region's leadership relative to other parts of the world. As a result, the Bay Area's ability to support economic growth and prosperity at the regional, state and national levels is increasingly at stake. To be sure, the region's innovation system is still functioning well and creating world-leading ideas and firms. But its historical success should not make us blind to the mounting issues and bottlenecks that affect it. If we wish to sustain and grow the region's ability to create jobs and wealth, it is essential to recognize these challenges and develop concerted responses.

[1] John Kao, *Innovation Nation* (New York: Free Press, 2007), 1.

This report assesses the Bay Area innovation system, its key components and how they work together, the pressures and uncertainties it faces, and how it fits into a changing global environment. It outlines key parameters around which the Bay Area innovation model is evolving, that enable it to partner with other regions in an increasingly networked world. Finally, the report makes recommendations for how decision makers in the region, in concert with those in Sacramento and Washington, can help meet these challenges and position the Bay Area's innovation system for continued success.

1.
The Bay Area Model of Innovation-Driven Economic Competitiveness

Disrupting existing establishments with new approaches, whether commercial, social or environmental, has always been part of the Bay Area's persona. It has long been a geographic frontier relative to the boundaries of the North American continent and the Euro-centric vantage point. It has also stood for a frontier of the mind, of lifestyles, science, new solutions to society's problems, and eventually of new technologies and business models which, taken to market, have been transformative for the nation and the world.

A distinct combination of structural and cultural components has provided fertile ground for the emergence of this system. Helped by immigration, military spending, federal and state investment, and the decisions of key business leaders since the end of World War II, the region's economy has been driven by the quest for the novel, the creative, and the heretofore untested. This paradigm contrasts with other industrial activities, such as the massively scaled manufacturing of goods, which focuses on increased output of standardized products and cost reduction per unit. Instead, value creation in the Bay Area has by-and-large focused less on the commoditization and scaling of these activities and more on their disruption, based on the development of products with high knowledge content that in many cases broke new technological and commercial ground.

As one result, activities and organizations that could not embrace this state of perpetual change have tended not to last long. Ultimately, the measure for success has been innovation and large-scale value creation in research, design and business process.

This report adopts the following definitions.

Innovation
Innovation is the creation of tangible value through novel processes, systems, products or services. It springs from ideas that combine new with existing knowledge, technologies, channels, networks, relationships and capital in order to meet needs or solve problems in superior ways.

Bay Area Innovation System
The Bay Area innovation system is an interactive cluster of diverse economic and social actors and institutions that flexibly partner to continuously test ideas and solutions in order to maximize value. Anchored by a highly developed capacity for science and technology

research and development, and drawing on a deep pool of human talent, it serves as a market place for ideas and a laboratory for experimentation and commercialization. The system spans a geographic arc from Santa Rosa in the northwest to Davis in the northeast, the Dublin–Pleasanton–Livermore Tri-Valley Area in the southeast and Santa Cruz in the southwest, encapsulating the core triangle of San Francisco–Oakland–San Jose/Silicon Valley.

Innovation-Driven Economic Development
Processes, products and services that originate in such an innovation system create distinct value chains and opportunities for economic development, which in turn generate employment, knowledge and income. Innovation-driven economic development looks beyond the traditional goal of attracting external investment, to promoting internal growth through entrepreneurship, the mobilization of local assets that provide competitive advantage, and the leveraging and deployment of those assets in a global setting.[2] This, in turn, attracts external investment, creating a positive feedback loop.

Innovation

Technology usually comes to mind when thinking of innovation. But actual innovation is much broader, including business model and process innovation. Apple's iPad, for example, is less a technological product (most of its components are made elsewhere) than a product of innovative design and the creative orchestration of complex inputs. While companies remain highly protective of their core technologies, "open innovation" describes a process through which innovation occurs not in proprietary silos but through open source, multi-party collaboration. This also suggests that innovation doesn't always emanate from one source, but can flow fluidly and in many directions, based on the domain expertise of its contributors and the market environments in which they work.

For innovation following any of these models to continue to produce economic growth and prosperity, the innovation system's core elements must be strong. As the 21st century commences, other regions across the globe have started to aggressively pursue aspects of this model. This development should not just be a wakeup call locally, but also nationally: the National Academies of Science have called attention to it in their *Rising Above the*

[2] For a detailed discussion of globalization and the innovation-driven economic development model, see *The Innovation Driven Economic Development Model: A Practical Guide for the Regional Innovation Broker*, a September 2008 report by the Bay Area Council Economic Institute and BASIC for the California Space Authority and the State of California.

Gathering Storm[3] reports, and more recently the White House Jobs and Competitiveness Council has made innovation a top priority.[4]

At the same time, it is important to note that innovation is not a zero-sum game. Hence, this report does not suggest that other regions or nations should not pursue innovation as successfully as the Bay Area or the United States. Prosperity-generating innovation is a net-positive phenomenon for all concerned. In fact, the emerging polycentric innovation paradigm, which is described in this report, requires complementary action and collaboration as well as competition between many actors across a networked world.

Converting Research to Marketable Products

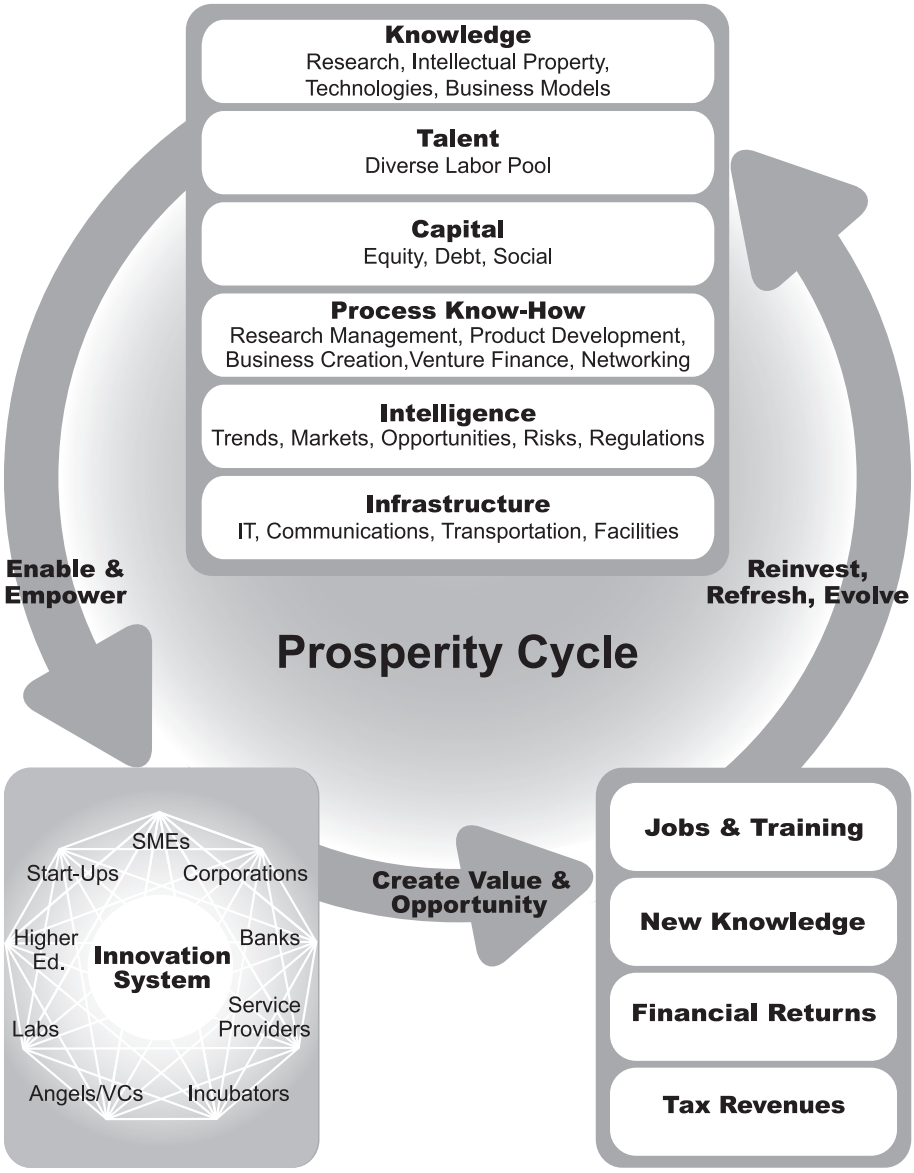
No description can do justice to every detail of the dynamics of an innovation system as complex as the Bay Area's. This analysis focuses on the activities and relationships that support the scientific research process and the conversion of its output into marketable goods and services.

The flow of assets, products and services between actors in the Bay Area is a virtuous cycle that feeds on its own success and produces positive economic effects far beyond its borders as actors from outside the region also participate. The flow of assets through the innovation system facilitates the success of the main creators of economic value—entrepreneurs, small and medium size enterprises (SMEs) and large corporations. Businesses convert research into marketable products, building on the flows of knowledge, talent, capital, process know-how, market intelligence and infrastructure that are the system's substrate. They create the jobs, revenue streams and tax revenues that translate into prosperity.

[3] National Academy of Sciences, National Academy of Engineering, and Institute of Medicine of the National Academies, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (2007) and *Rising Above the Gathering Storm Revisited: Rapidly Approaching Category 5* (2010) (Washington D.C.: The National Academies Press, 2007 and 2010).

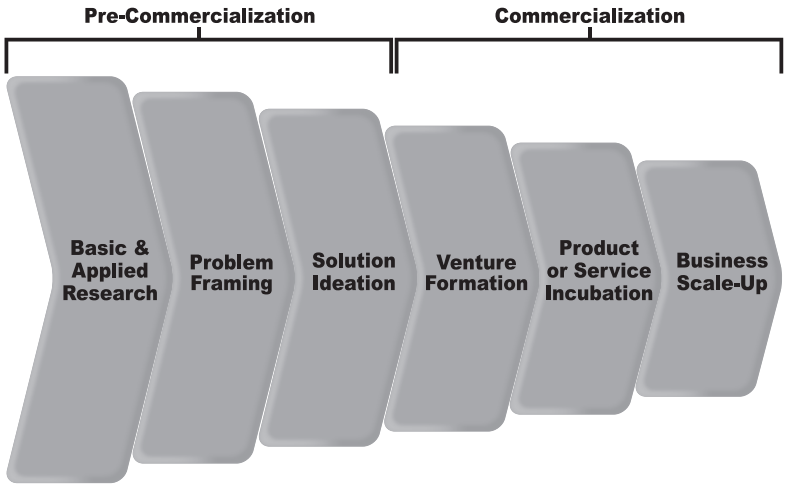
[4] Council on Jobs and Competitiveness, *Road Map to Renewal* (Washington D.C.: Council on Jobs and Competitiveness, 2011).

Flow of Assets in the Prosperity Cycle



The innovation process of converting research into value has different stages that connect. This "innovation value chain" is built on a foundation of basic and applied research, pulses across many domains, and ends with scalable products and services. In the Bay Area innovation system, the resulting products and services include not only information/communication technology and the Internet, with which the Bay Area has become synonymous, but also energy and environmental technology (cleantech), agriculture (as seen in the Napa and Sonoma wine industries) and life sciences. The knowledge produced through the value chain constitutes the base stock on which other actors draw, both systematically seeking and also serendipitously finding knowledge that—when applied or combined—yields powerful new insights and solutions.

Technology Innovation Value Chain



Innovation can come about through non-linear processes that are not tied to basic research, but occurs more through the collaboration of creative individuals, design, sensitivity to market and customer needs, and business culture. Non-linear innovation moves not just in one direction, but in positive feedback loops that can materially influence the development of products or processes. When this happens, the innovation value chain can become an "innovation cloud."

Supporting Services

As indicated above, the Bay Area innovation system consists of a complex web of actors: entrepreneurs, corporations, universities, national laboratories, capital providers (angel investors, venture capital and private equity, banks), incubators and accelerators, specialized service providers (IT, staffing, legal, accounting, strategy), design firms (such as IDEO and Frog[5]), and government (local, state and national). These actors have multiple relationships with each other, both formal and informal, and each play important roles in relation to the primary value creators—entrepreneurs, SMEs and large corporations. Often they have specialized expertise that cannot be easily developed inside a single organization, and through their interactions they create something that is often greater than the sum of its parts.

These actors seek to engage with each other as flexibly as possible, while continuously attempting to lower the transaction cost of doing so. The Bay Area innovation system is reasonably resilient and has proven that it can survive cycles and crises, notably the dot-com boom and bust and most recently the 2008 financial crisis. It has also repeatedly demonstrated its ability to build on prior achievements to evolve new technologies and applications, as evidenced by Silicon Valley's forty-year evolution from semiconductors to computers, the Internet, cleantech and cloud computing. More than once the region has been written off, only to revive and advance to new levels. However, it is not immune to damage when too much pressure is applied to its core structural underpinnings. This is especially the case when multiple pressures coincide at the same time. (See Section 5, *The Model Under Pressure*.)

> *"The legal and financial communities here know how to do IPOs, know how to do deals, and know the deal terms. Everybody understands how to make it happen. There's a huge maturity curve we've gone up here that's rare in the world."*
> — *Norm Winarsky, PhD*
> *Vice President*
> *SRI Ventures*

[5] Ranked by *Fast Company* as one of the Top 25 Most Innovative Companies, Palo Alto-based IDEO is a global firm that helps companies and brands create value by designing products, services, spaces and interactive experiences across a range of industries. Headquartered in San Francisco, Frog fields more than 1,000 designers, strategists and software engineers in twelve global locations, focusing on innovation in industries including consumer electronics, telecommunications, media, finance and fashion.

2.
The Bay Area Innovation System: Its Elements and Linkages

The Bay Area innovation system consists of multiple types of actors: universities and research institutions, finance (venture, angel, debt and private equity), incubators and accelerators, formal and informal networks, entrepreneurs, large businesses, and the specialized services that support them. This section explores these elements more closely.

At the core of the system is a powerful group of leading research universities and federal laboratories that are the pillars of the system and are critical to how it functions.

Higher Education: Public and Private

The Bay Area is home to a higher education network with global stature. At its confluence are major public and private universities with diverse capacities which generate both patented technologies and faculty and students who take those inventions to market.

Nationally renowned and globally recognized, Stanford University and the University of California at Berkeley are at the core, joined by UC San Francisco (a leading graduate-level health sciences campus), UC Davis and UC Santa Cruz. Other public education institutions, such as the California State University system, produce graduates with strong applied backgrounds; and the California Community Colleges support the four-year public system.

The Three-Tiered Public System of Higher Education

University of California (UC):
UC Berkeley, UC Davis, UC San Francisco, UC Santa Cruz

California State University (CSU):
CSU East Bay, CSU Maritime, San Francisco State University, San Jose State University, Sonoma State University

California Community Colleges (CCC):
Berkeley City College, Cabrillo College, Cañada College, Chabot College, City College of San Francisco, College of Alameda, College of San Mateo, Diablo Valley College, Contra Costa College, De Anza College, Evergreen Valley College, Foothill College, Laney College, Las Positas College, Los Medanos College, College of Marin, Merritt College, Mission College, Monterey Peninsula College, Napa Valley College, Ohlone College, San Jose City College, Santa Rosa Junior College, Skyline College, Solano Community College, West Valley College

Private Universities and Colleges (partial list)

Regionally-based institutions:
Stanford University, Santa Clara University, University of San Francisco, Dominican University, Golden Gate University

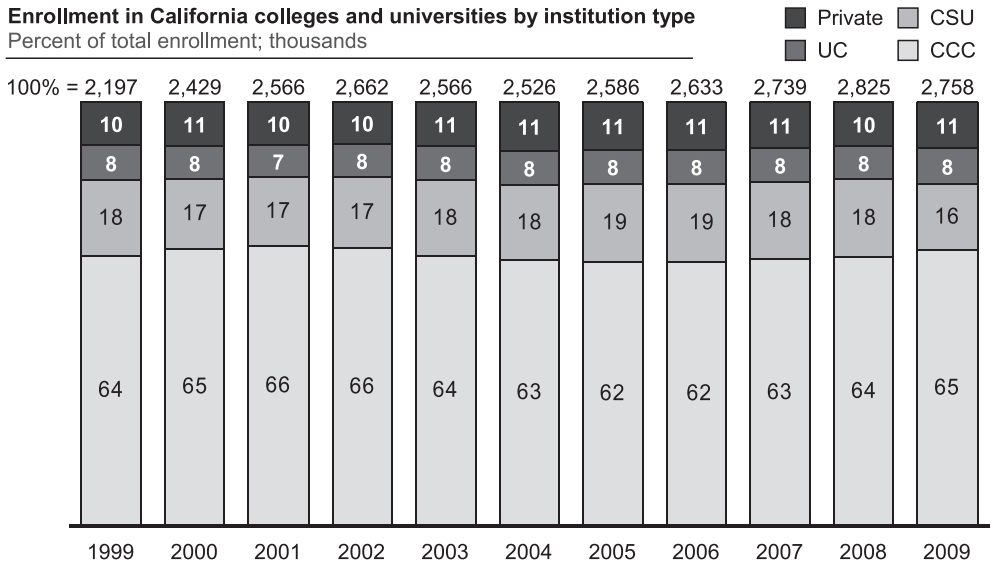
Regional campuses of national and international institutions:
Carnegie Mellon Silicon Valley, Wharton School/University of Pennsylvania, Babson College, Hult International Business School

Specialized educational institutions:
California College of the Arts, Presidio Graduate School, Academy of Art University, San Francisco School of Digital Film Making, Ex'pression College for Digital Arts, Cogswell College

As a source of primary input to the innovation system, the STEM (science, technology, engineering, math) and business programs of California's public higher education system have been critical to the health of the region's innovation system. Their importance is reflected in the fact that public institutions produce 90% of the graduates of higher education in California.

The Bay Area's four University of California campuses plus Stanford constitute the largest research university complex in the nation. In the aggregate, the region is home to more top-ranked graduate programs than anywhere in the nation and consistently attracts a large portion not only of federal investment but also of industry-sponsored research.

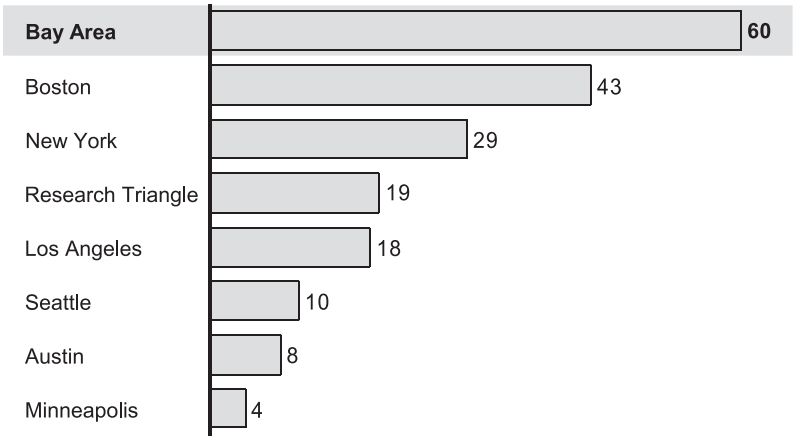
Public institutions provide 90% of higher education in California.



Note: 2010 data is not yet fully available by institution type
SOURCE: California Postsecondary Education Commission; Bay Area Council Economic Institute and McKinsey & Company Analysis

The Bay Area is home to more top 10 graduate programs than any of its peer regions.

Number of business, medical, science and engineering graduate programs ranked in the top 10 nationally[1]
Top graduate programs by region, 2011



1 Includes ranking for specialty programs (10 in business, 7 in science, 12 in engineering, and 9 in medicine). Total = 38 x 10 = 380

SOURCE: U.S. News Best Grad Schools 2011; Bay Area Council Economic Institute and McKinsey & Company analysis

Leading regional universities are responsible for a significant share of U.S. science and engineering R&D investment.

Total public and private science and engineering R&D investments[1] at U.S. universities and colleges, 2009

Regional university	Rank in R&D investments 2002	Rank in R&D investments 2009	R&D investments 2009 $ millions	CAGR 2002-2009 Percent
UC San Francisco	6	4	948	6.8
Stanford University	8	14	704	3.9
UC Davis	14	15	682	5.9
UC Berkeley	13	17	652	4.6
UC Santa Cruz	128	113	144	10.6

- The Bay Area has four universities ranked in the top 20 institutions[2]
- These 5 schools invest just over $3 billion on Science and Engineering R&D, 5.7% of total national spending

1 Investments include federal (DOD, DOE, HHS, NASA, NSF, USDA, other agencies), state and local government, industry, institution funds, and all other sources

2 U.S. institutions which invested at least $150K in R&D during FY2009

SOURCE: National Science Foundation, Division of Science Resources Statistics, Survey of Research and Development Expenditures at Universities and Colleges: FY 2008; Bay Area Council Economic Institute and McKinsey & Company analysis

Much of this research has direct economic applications. For example, Stanford, UC San Francisco and UC Berkeley together have played a key role in the development of the biotech industry.

Leading the Biotech Revolution

The biotech revolution was launched in 1973 and 1974 by three landmark papers written by Stanford professor Stanley Cohen and UC San Francisco professor Herbert Boyer with other colleagues from UC and Stanford (Paul Berg) that announced the discovery of recombinant DNA technology. Building on that and other work that started in the early decades of the 20th century, the Bay Area claims a remarkable number of pioneers who have been at the forefront of biotechnology innovation.

Genentech, founded in 1976 by Herb Boyer and venture capitalist Robert Swanson, was the first company founded on the basis of recombinant DNA. Genentech is now a wholly owned subsidiary of Roche, after being purchased in March 2009 for $46.8 billion.[6]

Ed Penhoet, a Berkeley professor, co-founded Chiron Corporation (since acquired by Novartis) with UCSF's Bill Rutter and Pablo Valenzuela in 1981. Penhoet returned to Berkeley as Dean of the School of Public Health in 1998 and is now a venture capitalist. Chiron's technology built on the work of Cetus Corporation, another Berkeley spin-off led by two Nobel Laureates who invented polymerase chain reaction (PCR), a major biotechnology tool.

Born in Hong Kong, and a Berkeley graduate and biochemistry professor, Robert Tjian founded Tularik, Inc. in 1991. The company is a leader in addressing human disease through techniques to regulate gene expression, transcription factors that turn genes on and off. Beginning with 60 employees and $3.9 million in capitalization, by the time of its IPO in 1999 Tularik had grown to 184 employees and an estimated market value of $350 million.[7]

Berkeley continues to generate biotech entrepreneurs. Corey Goodman founded Exelixis in 1994 and Renovis n 2001. Both licensed IP rights from his work (and that of Tito Serafini) as a faculty member at Berkeley. He then joined Pfizer and is now a venture capitalist with venBio and CEO of one of venBio's portfolio of companies, exemplifying the ways that talent circulates from academia, to industry, to private capital, and back to industry.

[6] Andrew Pollack, "Roche Agrees to Buy Genentech for $46.8 Billion," The New York Times, March 12, 2009, World Business.

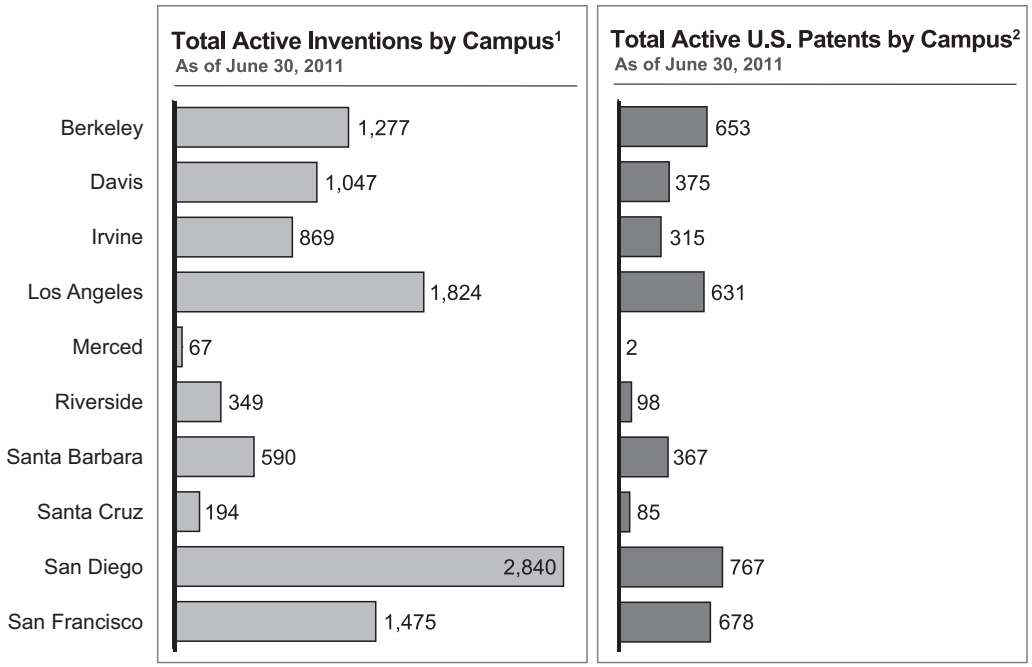
[7] UC Berkeley Library, "Biotech@25: The Founders" and "Biotech@25: Berkeley's Bioentrepreneurs," http://bancroft.berkeley.edu/Exhibits/Biotech/entre.html, (accessed June 1, 2012).

University of California

The University of California (UC) is the nation's leading public university and a world-leading research university. Of its nearly 235,000 students, 55,000 are graduate students and medical residents. Seven of the system's ten campuses are ranked in the top 100 universities globally[8] and together they are home to 57 Nobel Laureates.

UC is also a major generator of intellectual property, with 10,341 active inventions in FY 2011 and 3,900 patents. In FY 2011 alone, 58 start-up companies were created based on UC-originated technologies. In FY 2010, the UC system generated 75 companies, of which 62 are based in California.

The University of California is a major generator of inventions and patents.



1 Inventions associated with inventors from more than one campus are reported multiple times in this exhibit
2 Patents associated with inventors from more than one campus are reported multiple times in this exhibit
SOURCE: University of California Technology Transfer Annual Report 2011

Four of the University of California system's ten campuses are located in the Bay Area: UC Berkeley, UC San Francisco, UC Davis and UC Santa Cruz. Together with Stanford, they constitute the core of the region's innovation system. Collectively they have generated 3,993 active inventions, representing 39% of all UC-originated inventions. They hold 1,791 active patents, or 46% of all UC patents currently active. In FY 2011, 14 startup companies

[8] Economic & Planning Systems, Inc., *The University of California's Economic Contribution to the State of California*, (Oakland: The University of California Office of the President, 2011).

were formed based on technologies generated by the Bay Area's four campuses, representing 24% of the UC total. Across the UC system, 98% of start-ups locate within a 35-mile radius of the campus from which they licensed their intellectual property (IP) rights.

Technology transfer is managed by licensing offices at each campus and the office of the president of the UC system: UC Berkeley Office of Intellectual Property & Industry Research Alliances (IPIRA); UC Davis Innovation Access; UC Santa Cruz Office of Management of Intellectual Property (OMIP); UC San Francisco Office of Innovation, Technology and Alliances Management (ITA); Lawrence Berkeley National Laboratory Technology Transfer and Intellectual Property Management (TTIPM); and the UC Office of the President Innovation Alliances and Services (IAS).

Across the campuses, a diverse range of top-tier research institutes add specialization and subject matter depth. At Berkeley they include the Energy Institute; the Institute for Business Innovation (IBI); Renewable and Appropriate Energy Laboratory (RAEL); AMPLab (Algorithms Machines People); the Energy Biosciences Institute (EBI); the Synthetic Biology Institute; the Wills Neurosciences Center; and the new Simons Institute for the Theory of Computing. At Davis they include the Institute for Transportation Studies (ITS); the California Lighting Technology Center; the Institute for Innovation and Entrepreneurship; and the Beijing Genomics Institute; and at Santa Cruz, the Center for Network Systems.

AMPLab, for example, was founded in 2012 to focus on big data and related systems, with support from DARPA (the Defense Advanced Research Projects Agency), the NSF (National Science Foundation) and 18 private companies including Google, SAP, Amazon, HP, Oracle, Cisco, Microsoft and Intel. The Energy Biosciences Institute (EBI) was created in 2007 with a $500 million 10-year grant from BP. The world's first research institute focusing on bio-energy and the largest public-private partnership of its kind, EBI supports work by 60 research groups, 120 faculty and 200 postdoctoral students at UC Berkeley and the University of Illinois working on the development of plant-based biofuels.[9]

UC Berkeley

With slightly over 25,000 undergraduate and 10,000 graduate students, UC Berkeley is one of the world's great research institutions, hosting notable schools and departments in almost every major field of study. According to a 2010 National Research Council report, Berkeley has the highest number of top graduate programs in the country, with 48 out of 52 Berkeley programs ranked among the top 10 in their fields. In an

[9] Eli Kintisch, "Energy Research: BP Bets Big on UC Berkeley for Novel Biofuels Center," *Science Magazine,* February 2007.

analysis of National Science Foundation (NSF) Graduate Research Fellowships, the NSF found that from 2000–2009 more fellowships were awarded to students at UC Berkeley than any other university. (MIT placed second, Stanford third and Harvard fourth.) UC Berkeley's research productivity is reflected in 1,277 active inventions (171 disclosed in FY 2011), and 653 active U.S. patents (44 granted in FY 2011). Over 140 start-ups have been launched with UC Berkeley-originated IP since 1990 (5 in FY 2011).

UC Berkeley's Department of Electrical Engineering and Computer Sciences (EECS) has produced industry leaders such as Bill Joy, co-founder of Sun Microsystems, and Eric Brewer, founder of Inktomi (which was later acquired by Yahoo!), and has contributed to the development of technologies such as INGRES (Interactive Graphics and Retrieval System), which helped launch the relational database software industry in the Bay Area; RAID (Redundant Arrays of Inexpensive Discs); SPICE (Simulated Program with Integrated Circuit Emphasis), which enabled the integrated circuit design software industry; RISC (Reduced Instruction Set Computer); and BSD-Unix, which was a building block for contemporary computing and the Internet. All have materially contributed to the development of Silicon Valley and can be linked to well-known companies such as Oracle, PeopleSoft, Informix, Siebel Systems, Sybase, Cadence Design Systems, Synopsis and Salesforce.com.

Martin Kenney of UC Davis makes a persuasive argument that Silicon Valley's growth and development can be heavily attributed not just to EECS, but to the presence in the Bay Area of two leading university electrical engineering and computer systems programs (at Stanford and UC Berkeley) and their interplay with each other and with industry.[10]

The university also supports a diverse set of global research partnerships. For example, UC Berkeley along with Lawrence Berkeley National Laboratory collaborates with Nanyang Technological University and Singapore National University in Building Efficiency and Sustainability in the Tropics (SinBerBEST), an initiative connecting university, government and industry to develop technologies that radically improve building efficiency in tropical buildings. The university is linking the project with other building efficiency partnerships in the U.S., China (Tsinghua University) and Denmark (the Danish Technological Institute), to focus on energy efficient buildings across a range of climate types.

UC San Francisco

A graduate institution, UC San Francisco (UCSF) is the only campus in the 10-campus UC system focused solely on medicine and life sciences,

[10] Martin Kenney and David Mowry, "Electrical Engineering and Computer Science at UCB: Regional Engagement," working paper, (2012).

with schools of medicine, dentistry, nursing and pharmacy that rank among the best in the nation. Consistently ranked as one of the top 10 hospitals in the United States, the UCSF Medical Center has two sites in San Francisco—the original Parnassus campus and the university's new campus in Mission Bay, where a new 289 bed hospital will open in 2014 featuring specialized facilities for women, children and cancer patients. UCSF's new Mission Bay campus is being successfully leveraged by the City of San Francisco to attract biotech and pharmaceutical companies to locate on surrounding properties. While San Francisco had only one biotech company in 2004, as of 2010, it was home to 56 biotech companies employing 2,750 people. Most of these companies have located in Mission Bay.

UCSF also holds an outsized share of UC's IP generation. In FY 2011, the university had 1,475 active inventions and 678 active U.S. patents. Programs at the university specifically focus on "IP acceleration" to support the process of translating research innovation into public benefits. This includes commercialization and licensing, but can also focus on how to bring new practices to the forefront. The Bay Area's biotech industry (the nation's largest and most successful) and leading companies such as Genentech can be directly traced to UCSF and UC Berkeley faculty.

UC Davis

UC Davis, located near Sacramento, was founded as an agricultural campus, but has since evolved to become a large and diversified research center. In 2010–11 alone the university received $684.3 million in research funding, ranking it 10th in the nation for research dollars received by a public university and 15th for all research universities.

An example of the research conducted at UC Davis is the California Lighting Technology Center (CLTC), which specializes in technologies to accelerate the commercialization of energy-efficient lighting technologies. A collaboration between The California Energy Commission, the U.S. Department of Energy, and the national Electrical Manufacturers Association, CLTC serves as both as an education facility and a demonstration facility. While advanced technology research is comparatively recent, UC Davis remains one of the premier agricultural research centers in the nation, and it plays a critical role in supporting the state's wine industry.

The university has developed extensive research partnerships with other UC campuses through entities such as QB3 and the Joint BioEnergy Institute (JBEI) and with major industry partners such as Chevron and Agilent.

UC Santa Cruz

The newest and smallest of the region's four UC campuses, since opening in 1965 UC Santa Cruz has grown from 650 students to nearly 15,000 today. As a relatively young campus, it can't yet claim a large number of start-ups, but it has grown in importance as a research center. With approximately 2,000 people working on research projects, its research enterprise is the second largest employer in Santa Cruz County. The university has received more than $100 million in research funding in the last six years, and more than $1 billion over the past decade. *Times Higher Education World University Rankings 2011–2012* ranked UC Santa Cruz third worldwide for research impact, with a faculty score of 99.9, behind only Princeton and MIT. UC Santa Cruz's PhD program in computer engineering is ranked #1 nationally for publication impact, and UC Santa Cruz is ranked first nationally by *Science Watch* in per-paper research impact on physics and fifth nationally in space science.

Stanford University

In many respects the origins of Silicon Valley can be traced to Stanford, a private university founded on the principle that universities should not be ivory towers but instead should be intimately linked to the communities around them. The establishment of Stanford Research Park in 1946 on land immediately adjacent to the campus was a critical move that helped push technologies developed on campus into the private sector and enabled private businesses to more effectively engage the university's research community. Stanford's campus has since evolved as an integral part of the world's densest complex of technology companies and venture capital firms, concentrated in the communities of Palo Alto, Menlo Park, Mountain View and Sunnyvale.

Stanford's many research laboratories and institutes are closely linked to Silicon Valley. They include Geballe Laboratory for Advanced Materials; E. L. Ginzton Laboratory; W. W. Hansen Experimental Physics Laboratory; Kavli Institute for Particle Astrophysics and Cosmology; PULSE Institute for Ultrafast Energy Science; Stanford Institute for Materials and Energy Sciences; Bio-X; and Spectrum. Stanford University's Office of Technology Licensing, like MIT's, is considered a national model for the effective management and commercialization of intellectual property and technologies generated on campus, and it produces approximately $60 million in annual revenues.

While Stanford has made a major impact through the technologies produced by its research programs, its most significant economic contribution has been through its graduates, who have assumed leading roles in the region's corporate and research community and have founded many of its major companies including Agilent Technologies, Cisco Systems, Dolby Laboratories, eBay, E*TRADE,

Google, Hewlett-Packard, LinkedIn, Netflix, Sun Microsystems (since acquired by Oracle), Sun Power, Tesla Motors, Varian, VMware, Yahoo! and Zillow.

In addition to entrepreneurship programs designed for students, Stanford hosts the Innovation Corps, a six-month program funded by the National Science Foundation that trains scientists—typically professors or graduate students funded by the NSF—in the entrepreneurial skills that could eventually produce companies. Designed to help bridge the gap between laboratory research and technology commercialization by focusing on potential scientist entrepreneurs, the Innovation Corps has so far trained 45 teams in two sessions, and is poised to spread beyond the Bay Area to the University of Michigan and Georgia Tech.

California State University

The California State University (CSU) system is a primary source of technical talent (e.g., bachelor's and master's level engineers) for the region's innovation system. This mid-tier component plays a critical role in meeting workforce requirements that call for technical, hands-on skill sets below the PhD level. A 23-campus system with over 400,000 students, CSU awards approximately 90,000 degrees annually and since its inception in 1961 has conferred over 2.5 million degrees. Overall, it accounts for half of all bachelor's degrees awarded in California.

The key distinction between the UC and CSU systems was formalized in the 1960 California Master Plan for Higher Education, which allowed both systems to grant bachelor's and master's degrees, while giving only UC the ability to award PhDs. More than UC campuses, CSU campuses also tend to draw students from their immediately surrounding communities, often from families with comparatively modest means. The Bay Area hosts five CSU campuses, including San Jose State University.

CSU supports significant programs in applied research. Notable examples include the CSU Program for Education and Research in Biotechnology (CSUPERB), which supports biotechnology research and education across the CSU system with a focus on biotechnology and economic development in California, and the CSU Council on Ocean Affairs, Science and Technology (COAST), an extended network of CSU faculty, scientists and students that addresses the state's critical marine and coastal issues. COAST provides students in ocean science with a focused curriculum, hands-on experience and mentorship.

San Jose State University (SJSU) plays a particularly important role in the Bay Area's innovation system by generating large numbers of bachelor's and master's level graduates who serve as the technical backbone for many

Silicon Valley companies. Approximately 4,700 students study engineering alone, making SJSU's engineering program the largest in the region. With over 100 different programs and courses focused on entrepreneurship and innovation, students are immersed in the Silicon Valley culture. Specific programs include a six-week boot camp offering training in entrepreneurship, an annual innovation challenge competition, which has students competing for prizes based on their ideas, and the Silicon Valley Center for Entrepreneurship, which offers a curriculum developed in partnership with industry that fosters an innovative mindset.

In life sciences, the university's California Statewide Biotechnoloogy Clinical Laboratories Consortium Project, developed in partnership with the San Mateo County Health System and five Bay Area diagnostics companies, will create an education-to-employment pipeline for 200 licensed laboratory professionals, including medical laboratory technicians, clinical laboratory specialists and clinical genetic molecular biology scientists. With start-up funding from the federal government, the CSU system will take the system statewide.

Applied research is also important at SJSU. At Moss Landing Marine Laboratories, SJSU pairs master's candidates with marine science experts to conduct PhD-level research. A strong partnership with NASA Ames gives students the opportunity to work alongside leading researchers in a federal laboratory environment. With a local alumni base of 180,000, SJSU graduates 8,000 students per year and educates 30,000. Approximately 70% of SJSU graduates live and work in the Bay Area.

California Community Colleges

The California Community Colleges (CCCs) serve an important feeder function for the UC and CSU systems, enabling the diversity that is so important to a productive innovation system. By providing training and professional preparation for students who are often less privileged or may be the first in their families to pursue higher education, the CCCs fill an important niche in supporting a balanced, diversified economy.

In this context, community colleges provide industry with technical workers and provide workers who are unemployed or need to update their skills with transitional training. Community colleges also provide technically trained workers to meet the workforce needs of specific industries. For example, Skyline College benefits from donated equipment and offers courses developed in cooperation with Genentech to help meet that company's future workforce requirements. In another effort to seed the pipeline of future workers, City College of San Francisco is using a National Science Foundation grant to develop a high school curriculum on skills related to stem cell research.

The following figures show the under-acknowledged importance of community colleges to the innovation system: 70% of California's higher education students are enrolled in a community college and 25% of all community college students in the nation are enrolled in a California community college. Approximately 55% of CSU baccalaureate recipients start as community college students, and 30% of UC baccalaureate recipients are community college transfer students. Perhaps the most striking figure relates to innovation: 48% of UC baccalaureates in science, technology, engineering and mathematics are earned by community college transfer students.[11]

Foothill-De Anza Community College District

Located in Silicon Valley, the district is composed of two community colleges, Foothill and De Anza, which are closely connected to the Valley and its industries. The two colleges together educate approximately 70,000 students per year. One third of the students who report family income say it is under $25,000 annually. Foothill-DeAnza is also the community college system's top feeder to the University of California and the top feeder school to San Jose State University. Both Steve Jobs and Steve Wozniak took classes at DeAnza.

Foothill College added a new Life Sciences Building in 2007 and will open a new Physical Sciences and Engineering Center in 2013. The campus is also launching a new initiative, the Science Learning Institute, that will embody a cross-disciplinary approach to STEM education. The district expects to acquire nine acres this year at the former Onizuka Air Force Base in Sunnyvale to build a $38 million education center. Planned as a regional facility, the district is seeking partnerships with other colleges and universities, nonprofit organizations and industry. Foothill-De Anza and neighboring West Valley-Mission Community College District are developing coordinated programs for delivery at the education center site, and preliminary discussions are also under way with the San Jose-Evergreen Community College District. By leveraging resources at a site immediately adjacent to NASA Research Park, the center's goal is to more effectively support Silicon Valley's technical workforce needs.

Federal Research Facilities

No other region in the United States or in the world has more federally funded research centers and laboratories than the San Francisco Bay Area. The collection of Department of Energy, NASA, Department of Agriculture, and Veterans Affairs Administration facilities is unique and contributes significantly to the Bay Area's economy and innovation infrastructure. Federal investment in these institutions pumps billions of dollars into the local economy, spawns new businesses and industries, and provides job training for the region's thousands of undergraduate, graduate and postdoctoral students.

[11] California Community Colleges Chancellor's Office, "Key Facts," http://californiacommunitycolleges.cccco.edu/PolicyInAction/KeyFacts.aspx (accessed on May 10, 2012).

Department of Energy Laboratories

The largest federal investment in research facilities in the Bay Area is funded by the U.S. Department of Energy (DOE). The four DOE national laboratories in the Bay Area, Lawrence Berkeley National Laboratory, SLAC National Accelerator Laboratory, Lawrence Livermore National Laboratory and Sandia (California), collectively constitute an unparalleled national intellectual asset. They tackle large-scale, long-term research and development challenges that are typically beyond the scope of universities or industry. Functioning as an interdependent system of institutions with distinct capabilities and assets, they address scientific problems of national importance, supporting DOE's overarching mission of advancing the national, energy, and economic security of the United States.

The national laboratories complement the roles and capabilities of the region's academic and industrial research laboratories. They collaborate with universities in fundamental and applied research and partner with industry in technology development and deployment to enable the transfer of R&D to the marketplace. Their size and scope enable them to launch coherent multidisciplinary attacks on large-scale, complex problems, bringing value to industry and university partners in addition to their core national missions. Specifically, the national laboratories

- conduct research in physical, chemical, biological, and computational and information sciences that advance scientific knowledge;
- conduct research on clean energy technology;
- ensure the safety and reliability of the U.S. nuclear deterrent and help to prevent the proliferation of weapons of mass destruction.

National laboratories also design, build, and operate distinctive scientific instrumentation and facilities and make these resources available to the university and industry research communities. These designated "Scientific User Facilities" are in most cases available at no charge to researchers doing nonproprietary work. They include advanced light sources, supercomputers, sophisticated mass spectrometry, and high-resolution electron microscopy. These instruments and facilities, many of which are found nowhere else in the world, support both open scientific research and classified work. Applications include new materials, improved manufacturing processes, and advanced product testing. Few companies or universities have the financial and technical resources to design, construct, and operate facilities on this scale.

While the labs' core mission is non-commercial, in recent years they have diversified their focus beyond their primary client (the U.S. government) to include collaboration with the private sector on technology commercialization—in other words, economic development.

Lawrence Berkeley National Laboratory

Established in 1931 and managed by the University of California, Lawrence Berkeley National Laboratory (Berkeley Lab) was the first of the Bay Area national laboratories and is the oldest in the DOE national laboratory system. Conducting unclassified research in fundamental science and technology across a range of disciplines such as astrophysics, biosciences, life sciences, information technology, energy and environmental science, Berkeley Lab addresses compelling research issues—from understanding the nature and fate of the universe, to developing advanced biofuels that work seamlessly with today's stock of vehicles and fuel distribution infrastructure.

Located on 200 acres in the hills above the UC Berkeley campus, the lab employs nearly 4,200 scientists, engineers, technicians, and operations, facilities and administrative staff, making it one of the largest employers in the Bay Area. Almost 300 of the lab's scientists hold appointments at UC Berkeley and over 900 lab employees are undergraduate, graduate and postdoctoral students. The close proximity of these two major research institutions produces synergies not easily replicated elsewhere.

Berkeley Lab's FY 2011 budget of $735 million created over $1.6 billion of value added for the national economy, and its technologies have served as the basis for approximately 30 start-ups since 1990, creating 2,393 jobs—62% of which are in the Bay Area, and 90% in California.[12]

Its campus is home to several DOE National User Facilities, each with unique tools, resources and expertise, drawing thousands of external academic and industry researchers from throughout California, the nation and the world. The National Center for Electron Microscopy, for example, is home to the world's most powerful electron microscope, enabling scientists to view individual atoms with a resolution and clarity never before possible. Other major facilities include the Molecular Foundry, a national nanotechnology research facility; the Advanced Light Source (ALS), one of the world's brightest sources of ultraviolet light; and the National Energy Research Scientific Computing Center, one of the world's most powerful supercomputers, used annually by over 4,000 scientists.

Research at the ALS, for example, has applications across a range of disciplines and industries, including materials science, biology, chemistry, physics and environmental science. The pharmaceutical industry uses light sources such as the ALS for protein crystallography, a process important to the development of almost all new drugs. More than 40 large and small pharma companies have developed successful drugs

[12] CBRE Consulting, *Berkeley Lab: Economic Impact Study* (Berkeley: Lawrence Berkeley National Laboratory, 2010).

utilizing the ALS. The Molecular Foundry, which focuses on the synthesis, characterization and theory of nanoscale materials, draws a diverse range of users including biologists, chemists, physicists, biochemists, engineers and bionics and optics specialists, in fields spanning medicine, energy and computing.

In another team effort, Berkeley Lab is collaborating with the California Clean Energy Fund (CalCEF) in a public-private partnership called CalCharge that aims to speed the development of battery storage solutions in California. To help ensure that the domestic battery industry remains competitive, Berkeley Lab scientists and state-of-the-art equipment will be available to the state's more than thirty energy storage companies working on batteries for computing, energy storage, electric vehicles and other applications. CalCEF will contribute its funding and company-building expertise.

Berkeley Lab also leads the Joint Genome Institute and the Joint BioEnergy Institute, described below.

Berkeley Lab's Future Richmond Campus

In January 2012, the University of California announced plans to open a second campus in order to consolidate the bioscience programs of Berkeley Lab. Currently the bioscience programs of the Lab are dispersed over 5 sites that span a distance of 25 miles. The merging of these into a single research park will create a world-class center for bioscience matched only by the comparable biomedicine Harvard-MIT Broad Institute in Cambridge. The proposed center is targeted to have 800 employees and 300,000 gross square feet of new facilities, including a commercialization office to facilitate technology transfer. Tenants would include the Joint BioEnergy Institute, the Joint Genome Institute and the Lab's life sciences research program, aggregating assets to support closer collaboration.

Lawrence Livermore National Laboratory

Established in 1952 in the Livermore Valley by the University of California, Lawrence Livermore National Laboratory (LLNL) was created as a national security facility with the goal of ensuring the safety, security and reliability of the nation's nuclear weapons arsenal. National security, and nuclear energy in particular, remain its core focus, with the additions of strategic programs in bio-security, counterterrorism, defense, energy, intelligence, nonproliferation, science and technology, and weapons and complex integration. With a budget of $1.5 billion, LLNL employs 7,000 people and is home to world-class facilities that are unique to its fields of research. Its National Ignition Facility (NIF), which contains the world's largest high-energy laser, is a major tool in the advancement of fusion energy.[13]

[13] Lawrence Livermore National Laboratory, "About NIF," https://lasers.llnl.gov/about/ (accessed June 1, 2012).

In early 2012, the High Performance Computing division took delivery of its new "Sequoia" computer from IBM. The Sequoia is capable of performing calculations at the rate of 20 petaflops (or 20 thousand trillion calculations per second) and during tests running at approximately 81% efficiency, it qualified as the world's fastest supercomputer.

Like its sister national laboratories, LLNL is expanding its focus beyond its national security mission to include technology commercialization and economic development. In FY 2011, the lab was awarded 60 U.S. patents, filed 123 patent applications, and submitted 164 records of invention. It also signed six new Cooperative Research and Development Agreements (CRADAs) with industry partners and 24 new commercial licenses for LLNL-developed technologies and software.

Its commercial licensing program ranks at the top among national labs. Though economic development is a relatively recent focus, the benefits are starting to show. Four companies (Cadence Design, Cepheid, Digital Globe and Rambus) founded by LLNL scientists now have a collective market value of over $8 billion. Quantalife, another licensee, was recently purchased by BioRad for $180 million. Its Droplet Digital PCR technology, which allows the study of biological systems at unprecedented levels of resolution, emerged from LLNL research on bioweapons detection, received venture capital funding and, when commercialized, will enable the earlier detection of disease and improved targeting of therapeutics. In FY 2010, $400 million in goods with "LLNL inside" were sold in the U.S. Further benefits may come from its High Performance Computing Innovation Center (HPCIC), which was created in 2011 to facilitate partnering with U.S. industry on high-performance computing solutions.

The High Performance Computing Innovation Center

LLNL's High Performance Computing Innovation Center (HPCIC) leverages decades of U.S. investment in computing for industry partnerships. Located on the Livermore Valley Open Campus (LVOC), it provides a platform for over 100 universities, laboratories and industry partners to engineer, test and deploy high performance computing solutions across a wide array of applications through access to the LLNL's sophisticated computing hardware.

In June 2012, IBM announced that it will locate its High Performance Computing research unit at the Open Campus, to collaborate with LLNL's HPCIC under the name Deep Computing Solutions. Focusing on the development of technological tools for U.S. industry, the partnership will be supported by researchers drawn from both IBM and LLNL, and a new five petaflop system that will bring total computing capacity at the Open Campus (when added to Sequoia) to 25 petaflops.

Other externally focused initiatives reflect the lab's movement toward greater business and community engagement:

- LLNL has a Memorandum of Understanding (MOU) with the Keiretsu Forum, the world's largest network of angel investors, through which the forum's expertise in structuring, investing in and implementing "go to market" strategies will be applied to LLNL's portfolio of technologies available for commercialization. Its initial emphasis is on developing a process for evaluating technologies and market opportunities and moving forward with those that are considered most promising.
- LLNL hosted an Entrepreneurship Academy in the summer of 2011 in which 16 San Francisco Bay Area college students working in four teams gained firsthand experience in developing business plans for commercializing LLNL technologies. To make the program as realistic as possible, entrepreneurs who have successfully commercialized LLNL-developed technologies were brought in to advise the students and judge their business plans. Three teams focused on technologies related to health care and one focused on fuel-cells.[14]
- One of the most potentially impactful initiatives at LLNL is a proposal, now pending before the state's Public Utilities Commission, to partner with California's three investor-owned utilities—PG&E, Sempra, and Southern California Edison—to use its High-Performance Computing simulation capabilities to model and plan future energy systems. If approved, this could include how the grid incorporates the large-scale coming online of renewable power, how it accommodates the increased use of electric vehicles, and how it addresses cybersecurity. Collaboration will be open to university and other partners.

Sandia National Laboratories

Sandia National Laboratories is headquartered in Albuquerque, New Mexico, with its second campus in Livermore, adjacent to LLNL. Founded in 1949, Sandia's research focuses on five key areas: nuclear weapons; energy, climate and infrastructure security; nonproliferation; defense systems and assessments; and homeland security and defense.

Sandia employs approximately 1,200 individuals in California, nearly all located in the Bay Area. It is also the most engineering-focused of the national laboratories in California and applies that expertise to partnerships with multiple universities, including UC Berkeley, UC Davis, UC San Francisco, Stanford and Harvey Mudd College in Southern California.

[14] Lawrence Livermore National Lab, *Science and Technology in the National Interest* (Livermore: Lawrence Livermore National Lab, 2011).

In 2010, Sandia funded more than $2.1 million in projects with California universities for work that supports Sandia programs.

Sandia also maintains a number of knowledge exchange projects with industry. In particular, its transport division has collaborated with GM, Ford, Chrysler, Cummins, Caterpillar, John Deere, Detroit Diesel Corporation, Navistar, Mack, Exxon, Chevron, BP, Shell and Conoco Phillips to improve automotive engine design and fuel efficiency. These collaborations allow Sandia researchers to publish (which isn't the case for national security work) and allow industry researchers to benefit from accelerated access to cutting-edge science. The results, which focus more on knowledge than hardware, can be concrete: largely based on Sandia research, Cummins produced an engine in 2007 that achieved a 10–15% cost reduction and a 10% efficiency improvement over its previous generation engine.

Other recent collaborations include working with banks on network security; working with Silicon Valley companies such as Google to test hardware for user data protection; and installation of bio-threat detection at public facilities such as the Oakland Coliseum, the 2008 Democratic Convention, and San Francisco International Airport.

Sandia is also the program lead for i-GATE (Innovation for Green Advanced Transportation Excellence), a regional public-private partnership centered in the Bay Area's Tri-Valley region. i-GATE is one of the California innovation hubs (iHubs) designated in 2010 by the Governor's Office of Economic Development and serves primarily as an incubator, both to support entrepreneurs and to maximize the impact of green transportation and clean energy technologies.

Livermore Valley Open Campus (LLNL and Sandia)

In a major effort to engage with entrepreneurs and accelerate the movement of lab-originated technologies into the commercial realm, LLNL and Sandia are collaborating to create the 110-acre Livermore Valley Open Campus (LVOC). In locating the campus on property between Livermore and Sandia, their strategy is to take traditionally sequestered national laboratory research and create an environment—outside the security fence—that is accessible to business and the public and will foster collaboration between laboratory scientists and their peers in industry and academia. Research will initially focus on areas where the two labs have traditionally excelled: high performance computing, cyber security science, combustion research, transportation research, high energy density physics, and climate and energy research. One significant program currently operating as part of the Open Campus is the High Performance Computing Innovation Center described above.

SLAC National Accelerator Laboratory

Operated by Stanford University for the U.S. Department of Energy, SLAC National Accelerator Laboratory is a DOE Scientific User Facility and home to the world's longest linear accelerator. Thousands of scientists come from around the world to use its facilities each year, and six researchers have been awarded the Nobel Prize for work done while at SLAC. Originally created to do particle physics research, SLAC has since become a hub for astrophysics, photon science, and accelerator physics. The main component on NASA's Fermi Gamma-ray Space Telescope, the Large Area Telescope (LAT), was designed and built by SLAC. Users have access to three major facilities: the Facility for Advanced Accelerator Experiment Tests (FACET), the Linac Coherent Light Source (LCLS), and the Stanford Synchrotron Radiation Light Source (SSRL).

Other Federal Research Laboratories

NASA Ames Research Center

Located in the heart of Silicon Valley, NASA's Ames Research Center (ARC) employs 2,500 researchers, scientists and technology developers, has an annual operating budget of $750–$800 million and utilizes over $3.0 billion in capital equipment. Ames researchers focus on a range of disciplines from bioscience to astrophysics. The Center is home to NASA's Astrobiology Institute, the Lunar Science Institute, the NASA Aeronautics Institute, and the NASA Research Park which hosts a dynamic research and education community. ARC's Innovative Partnerships Office, in the Technology Partnerships Division, facilitates collaborations with industry, universities and other government agencies to "spin-in" and "spin-out" technologies and initiate cost-shared joint-development partnerships. Collaborations focus primarily on technologies that align with or potentially support NASA's space mission.

Sustainability Base, a new net-zero energy facility, is simultaneously a working office space, a demonstration "smart building" and a showcase for NASA technology, adapting software systems originally engineered for aviation and space travel for use in a building environment. Reflecting the collaborative model that is common in the Bay Area, ARC is engaged with Lawrence Berkeley National Laboratory to use its Building Information and EnergyPlus models for energy performance simulations.

The ARC Space Portal was established in 2005 to accelerate development of a new space economy by providing a "friendly front door" for organizations outside of NASA to work with NASA and other entities on commercial space activities for the public benefit. It provides commercial access to NASA facilities and expertise and facilitates relationships

among suppliers of commercial space services, potential customers and interested investors. The impacts of its activities can be seen nationally in numerous economic development and commercial and non-commercial enterprises that support the development of the commercial space sector. One of the most significant relationships is with SpaceX, which was established by Elon Musk (founder of PayPal and CEO of Tesla Motors) in 2002 to develop cost-effective, commercial space launch vehicles linked to the emerging market for private and commercial space transport. Since then, the company has developed two launch vehicles and is funded by NASA to demonstrate the delivery and return of cargo for the International Space Station with the goal of ultimately replacing the cargo transport functions of the Space Shuttle. ARC's support and contributions include the PICA heat shield material used by the Dragon spacecraft, which in May 2012 was launched on its inaugural flight to the International Space Station.

With 675,000 square feet of building space and 55 active partners, NASA Research Park is perhaps the most important Ames Research Center initiative that connects to the community. With the objective to create a shared-use R&D and education campus for industry and academia, since the launch of commercial leasing in 2003 the Park has developed 70 agreements with a diverse range of partners, including Carnegie Mellon University and Foothill-DeAnza Community College District.

To date, NASA's Ames Research Center has helped launch 35 start-ups through R&D spin-outs, partnerships and licenses, including most notably Nanostellar (which applies the use of nanomaterials to chemical production, fuel production, waste heat recovery and diesel catalytic converters), Tibion Corporation (which now manufactures bionic orthotics that robotically enhance the wearer's movements, based on original research to address the problem of astronaut muscle atrophy during space flight), and Bloom Energy (a cleantech company now valued at nearly $3 billion).

Bloom Energy

Bloom Energy's CEO, Dr. K.R. Sridhar, a former ARC researcher, started the company with a solid oxide fuel cell technology originally developed to convert Martian atmospheric gasses into oxygen. Bloom's "Energy Servers" now deliver clean, highly-efficient energy through fuel cell systems providing on-site power for commercial and industrial facilities. "Bloom Boxes" are currently installed on a number of business campuses including eBay, Google, Kaiser, Staples and Walmart. With a workforce of 1,500, Bloom has announced plans to hire another 1,000 in Silicon Valley, and 1,500 at a new facility in Delaware.

Joint Genome Institute

Managed for the U.S. Department of Energy by Berkeley Lab in partnership with LLNL, the DOE Joint Genome Institute (JGI) is a Scientific User Facility focused on the support of DOE goals and missions through application of large-scale genomics and analysis of plants, microbes, and communities of microbes. It is the only genomic sequencing facility in the world dedicated to non-human genomes. With an operating budget of $70 million for FY 2012, JGI's facilities provide scientists with access to state-of-the-art genomic tools. This supports other national laboratories that need specialized tools and researchers, while also developing a community of information sharing. The Joint Genome Institute had 1,713 unique users in FY 2011, published 188 papers in scientific journals, and had a team of 475 investigators for a single genome sequence project published in *Science*.

San Francisco Veterans Administration Medical Center

The VA hospital in San Francisco is home to the Northern California Institute for Research and Education (NCIRE), the largest research program in the national Veterans Health Administration's system. With $80 million in funding from the National Institutes of Health, other federal agencies and private sponsors in 2011, its research particularly focuses on issues impacting veterans, including cancer, hypertension, stroke, heart disease, Alzheimer's and traumatic spinal cord and brain injuries. NCIRE is jointly staffed through the San Francisco VA Medical Center and the University of California, San Francisco.

Veterans Administration Palo Alto Health Care System

The VA hospital in Palo Alto is home to the second largest research program in the Veterans Administration's system, with $58 million in research funding in 2011. Its nonprofit corporation, the Palo Alto Institute for Research and Education (PAIRE), is affiliated with Stanford University and has 180 principal investigators and 500 research projects underway at any given time. Areas of research focus include geriatrics, mental health, schizophrenia and HIV.

Collaborative Research Facilities

Collaborative labs are facilities created by universities or federal laboratories to facilitate collaborative research with each other or with the private sector. Launched by government, they invite private funds and link the basic research capabilities of the public sector with the market-orientation of business, to accelerate the movement of research from the laboratory into the commercial marketplace.

California Institutes for Science and Innovation

Four California Institutes for Science and Innovation (CISI) were created by the State of California in 2000 to foster collaboration between UC campuses (two to four campuses depending on the Institute) and industry in areas of innovation considered critical to the state. Together they constitute a promising model for engaging the business community and leveraging cross-institutional capacities in a resource-constrained federal and state budget environment. Of the four CISIs, two are located in the Bay Area—QB3 and CITRIS.

QB3

QB3 (the California Institute for Quantitative Biosciences) employs the tools of physics, chemistry and computer science to advance the field of biology. A cooperative venture between UCSF, UC Berkeley and UC Santa Cruz, QB3 is designed as an interface of university research with the private sector, including both major companies and start-ups. Research focuses on fundamental biological science, but with an ultimate eye to potential applications such as targeted drugs. Research is built around not just funding, but shared problem solving. The three participating UC campuses contribute based on their respective strengths: UC Berkeley doesn't have a medical school, so can access UCSF for clinical work, while its strength in engineering brings computational capacity to the table. UC Santa Cruz brings strength in informatics. QB3 now hosts 220 research labs, and has helped launch 65 companies, which together have raised $230 million in capital.[15]

QB3 actively partners with the City of San Francisco both to attract pharmaceutical companies to Mission Bay and to support start-ups as a means of building a significant biotech sector in the city. Both efforts explicitly leverage Mission Bay and the capabilities of UCSF. The presence of both big pharma and small companies has proven to be attractive. Current biopharma residents of Mission Bay include Fibrogen, Merck, Pfizer, Bayer, CalGene and Nektar.

Reflecting the Bay Area's model of collegial problem solving, Mission Bay also hosts a "science hotel" where researchers from across the country can rent space for as long as they need to jointly address research issues. QB3 is frequently asked by foreign governments to collaborate, but finding a win-win formula has proven challenging (since the activity must in some respect benefit California). Malaysia currently sends fully paid students, an arrangement that provides $40,000 per student per year to the supervising principal investigators. Space is also being provided for a translational research center sponsored by Canada.

[15] California Institute for Quantitative Biosciences, "About," http://qb3.org/about (accessed June 1, 2012).

Fostering Entrepreneurs at QB3

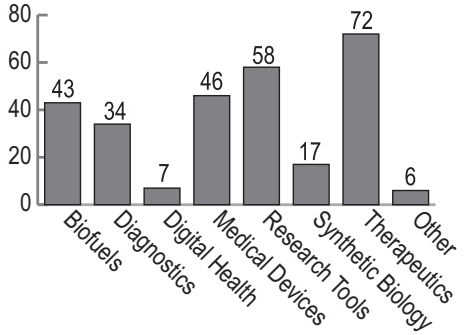
QB3 has pioneered efforts to commercialize technologies not just through industry collaboration but by supporting and incubating start-ups led by QB3 faculty and staff. Its program was launched in 2006 with $3 million ($1 million per year) from the Rogers Family Foundation, with another $3 million committed more recently. This funding has supported an in-house incubator, where research scientists and graduate and postdoctoral students developing technologies with potential commercial applications can test their viability. The "Start-Up in a Box" program, launched in 2011, provides a suite of support services such as free checking accounts, training on how to access small business grants, and access to patent lawyers. "The Garage" provides office space and access to shared equipment (for which the participants are charged). Beginning with just 2,500 square feet, the Garage has expanded to include five locations in Mission Bay and Berkeley.

Continuing its build-out of supporting services, QB3 has also created a venture fund, for which $11.3 million has been raised to date, one third of which has been disbursed to eight companies. While focused primarily on The Garage and UC, the funding can be directed anywhere in California. This is very early stage finance (with 80% of the proceeds returned to its limited partners and 20% to the university), in contrast to support from the Rogers Family Foundation which can be characterized as "venture philanthropy."

In their six years of operation, QB3 and The Garage have helped launch 60 new bioscience companies, which to date support 280 jobs and have attracted $226 million in follow-on funding. Of the 60, 45 are still in the incubators, and 13 have moved into commercial space or have been acquired by larger companies. Only two are no longer in business. More than a third of the companies are direct spin-offs from UC laboratories, while the rest are led by entrepreneurs who sought out QB3's incubators for their proximity to UCSF's research.

Examples include Fluxion Biosciences, a research tools company launched by a UC Berkeley graduate student that raised more than $16 million in venture funding and brought four cell-analysis devices to market to aid in drug discovery and research; Omniox, a cancer therapeutics company led by a team of Berkeley and UCSF graduates, which raised $4 million in U.S. Small Business Administration Innovation Research (SBIR) grants; and Refactored Materials, a venture-funded UCSF spin-off that is using synthetic biology to produce spider silk.

Jobs Created by QB3 Start-Ups



SOURCE: www.ucsf.edu/news

CITRIS

CITRIS (the Center for Information Technology Research in the Interest of Society) focuses on information technology solutions that benefit society at large, while also striving to shorten the pipeline between basic research and commercialization. A cooperative venture between UC Berkeley, UC Davis, UC Merced and UC Santa Cruz, CITRIS occupies 141,000 square feet at its headquarters at Berkeley and has a network of more than 300 faculty members and thousands of students from each of the four campuses.

CITRIS currently has over 100 research projects under five initiatives:

- i4Energy Center: IT, Sensors, and Controls for Stable and Sustainable Energy
- Delivering "Quality Health Care Everywhere" for Californians
- Intelligent Infrastructures: Water, Transport, Cities
- Generating Insight from "Big Data"
- Data and Democracy

Beyond the CISIs, which are UC-based, the University of California has also partnered with federal and private university partners to create even broader collaborations, most notably the Joint BioEnergy Institute (JBEI).

Joint BioEnergy Institute

Located in Emeryville and created in 2007 by the U.S. Department of Energy as one of three national BioEnergy Research Centers, the Joint BioEnergy Institute (JBEI) is a partnership led by Berkeley Lab that includes UC Berkeley and UC Davis, LLNL and Sandia National Laboratories, and the Carnegie Institution for Science. Established with the goal of advancing the development of biofuels through synthetic biology and engaging six national laboratories and universities in close proximity, the Joint BioEnergy Institute enables its partners to accelerate research by concentrating their efforts.

JBEI was established with five years of funding ($135 million), and a staff of 170. Its contributions to the Bay Area, California and national innovation economies are best seen in its fuel and technology trials with renewables. To date, JBEI has produced one spin-off, Lygos, which uses sugar as feedstock to create a replacement for petrochemicals in the manufacture of products from nylon to plastic. Lygos now has office space in QB3's innovation center located in Mission Bay.

California Institute for Regenerative Medicine

Created with the passage of Proposition 71, the California Institute for Regenerative Medicine (CIRM) is a taxpayer-funded grant-making agency whose mission is to advance the use of stem cell research for medical applications. With $3 billion in initial capital, CIRM funds research at both for-profit and not-for-profit institutions but conducts no research itself. Its location adjacent to Mission Bay and UCSF's Mission Bay campus underscores the growing importance of San Francisco as a biotech hub. To date, CIRM has awarded nearly $200 million in funding to Stanford, $120 million to UCSF, $66 million to UC Davis, $52 million to UC Berkeley, $36 million to the Buck Institute for Research on Aging, $28 million to the Gladstone Institutes and almost $23 million to UC Santa Cruz, among others. CIRM has also increased the long-term capacity for stem cell research in California by helping fund 12 new stem cell laboratory facilities throughout the state, including research centers at Stanford, UCSF, UC Davis, the Buck Institute, UC Berkeley and UC Santa Cruz.[16]

Corporate Laboratories

Corporate research laboratories complement the work of universities and federal labs, focusing less on fundamental research than on product-related applications. With a few notable exceptions (e.g., IBM and HP), commercial applications and value creation are the primary focus.

Corporate R&D units often connect to corporate business units and corporate venture capital groups as well as central technology development departments. In this capacity they can serve as feeders for venture spin-offs, and as catalysts and scouts for innovation "spin-ins" (a term popularized by the Bay Area's Cisco Systems, which defines it as the acquisition and scaling up of a small start-up internally).

Reflecting the magnitude of regional R&D conducted in 2011, the Bay Area corporate R&D units of Agilent, Genentech, HP, IBM, Intel and Xerox alone spent over $24 billion on research projects.[17]

University and federal laboratory collaborations are central to the corporate labs' business models. For example:

- Agilent Technologies has active research partnerships with Stanford, UC Berkeley and UC Davis, as well as universities outside the Bay Area such as Harvard and MIT. Proximity to Agilent's large R&D sites in Santa Clara and Santa Rosa is a significant advantage for

[16] Don Gibbons, "California stem cell agency, donors and 12 California institutions commit $1.1 billion to increase the capacity for stem cell research in California," CIRM Press Release, May 2008.

[17] Aggregated from corporate reports and websites.

Bay Area partners. In addition to tapping into the portfolios of university laboratories, corporate-university partnerships are used to sense where the leading edge in technology and markets is heading. Such partnerships become increasingly important as the level of research and its novelty becomes more advanced.

"Agilent Research Laboratories focus on breakthrough, disruptive technology. We're a global organization, but the majority of this investment is here in the Bay Area because of its extraordinary wealth of top academic talent and research capability in very close proximity. Through our geographic and cultural linkages, the Bay Area is also extremely well positioned as a conduit to the increasingly important innovation markets in China and throughout Asia. "
— Darlene J.S. Solomon, PhD
Senior Vice President & CTO
Agilent Technologies

- Oakland-based Kaiser Permanente's Division of Research (DOR), the largest medical research center in the nation not affiliated with a university, regularly collaborates with UCSF, Stanford and UC Berkeley's School of Public Health.

- IBM Research–Almaden funds and collaborates with CITRIS on natural resource and data analytics and supports faculty awards and student scholarships, principally at UC Berkeley and Stanford. IBM scientists teach at Stanford, UC Berkeley, San Jose State and Santa Clara Universities, and the Almaden lab recruits staff, postdoctoral students and interns from all four universities. Almaden also conducts joint research with Berkeley Lab.

"This is where it happens, why everybody's here."
— Michael Karasick, PhD
Vice President
IBM Research–Almaden

- HP Labs works closely with researchers at Stanford, UC Berkeley, UC Davis and UC Santa Barbara, as well as Georgia Tech, University of Michigan and MIT. Many lab members serve as faculty at Bay Area universities, presenting opportunities to engage the company's future workforce. Doctoral students are also engaged as interns, with HP staff frequently serving on their thesis committees. Between 50 and 75 grants are awarded each year to PhD students, deepening the lab's connections with both students and professors.

- Through its Advanced Technology Center (ATC), which creates the technology foundation for the company's Space Systems business, Lockheed Martin collaborates on science programs with NASA's Ames Research Center, as well as Stanford, UC Berkeley, and Lawrence Livermore and Sandia National Laboratories. Instruments built by ATC are riding aboard NASA's Solar Dynamics Observatory

(SDO), and the Center is currently building spacecraft and instruments for NASA's next solar mission, the Interface Region Imaging Spectrograph (IRIS).

In addition to hiring large numbers of students from Stanford's aeronautics and astronautics, physics and engineering departments, Lockheed Martin co-leads with Stanford a solar and astrophysics center of excellence. Perhaps their best-known collaboration with Stanford is the Gravity Probe B program that recently validated two effects of the general theory of relativity and led to over 100 PhD dissertations. This solar and astrophysics research uniquely anchors Lockheed Martin in the Bay Area as well as in Denver.

As one corporate research leader interviewed for this study observed, even competitors can collaborate through universities, which provide a safe environment for the open exchange of ideas and enable companies to conceptualize solutions in areas where it's difficult for one company to move alone: "It's in the university setting that you can actually talk about what might be. And there really isn't any other place in the world where that happens, except maybe MIT and Georgia Tech. So having this in California is a big deal. In spite of everybody trying, it isn't flourishing anywhere else."

Corporations have many global choices for where to locate labs, as growing numbers of countries offer incentives and favorable conditions for R&D. But all of the lab representatives interviewed for this study stated that the value added by a presence in the Bay Area is of a scale and diversity unmatched in other geographies. They quote four different types of essential flows: first and foremost, the two-way talent-exchange between universities and corporate labs; second, the ad hoc exchange of research insights through guest lectures, brown-bag lunches and informal networking events; third, the long term rapport and trust that, once established, lends itself to conversations that can rapidly qualify or disqualify an idea; and fourth, the exchange and hand-off of research projects from one institution to another if resources there are better aligned. The importance of these informal networks is difficult to overstate: a network exists in the Bay Area where in industry, "you probably know someone at every significant company in the [Silicon] Valley."

Technology Transfer Accelerates Commercialization

Research done at PARC, a Xerox Company produced a technology for detecting rare cells in the bloodstream, during a time when PARC was attempting to create a portfolio of biomedical technologies. Over time, however, PARC realized that it did not have a sufficient core of life sciences expertise to support these projects and concluded that the technology would be better utilized at an institution with a stronger focus on life sciences. In 2011, this technology was therefore transferred from PARC to SRI, which has a major investment in biomedicine and its applications. The technology—a system for identifying a small number of rare cells surrounded by billions of normal cells—has major implications for cancer and stem cell research. The transfer was made possible by the close relationship between PARC and SRI, based on previous joint government contracts and reciprocal visits of staff between the institutions.

The Bay Area is also a focal point for potential global partners. For instance, the government-owned King Abdullah City of Science and Technology (KACST) in Saudi Arabia has engaged with IBM Research–Almaden to launch projects in low-cost photovoltaic energy, desalination membranes, and clean chemistry. These projects benefit from Almaden's deep research in areas that leverage its semiconductor and related IT and materials expertise while utilizing the KACST systems engineering capabilities—a complementary, non-competitive relationship.

Bay Area-based companies that operate major research facilities are joined by a host of U.S. and overseas corporate research laboratories seeking to tap into Bay Area expertise and participate in the region's innovation system. For many companies, the need to be at the cutting edge of developments in their industries makes a Bay Area presence essential. By participating in the Bay Area's innovation system, they can co-create new technologies, connect with other global partners, and in the end shorten product development cycles. As one sector example, nearly all of the leading U.S. and overseas auto companies have Bay Area research centers, primarily to enable the more rapid incorporation of new IT developments in future product lines. In the ICT space, U.S. and overseas-based companies are locating research facilities and accelerators in the region in order to be close to the latest developments in cloud computing, to market changes driven by the proliferation of mobile devices, and to the region's large community of applications developers.

Corporate Research Center Presence in the Bay Area (Partial List)

Bay Area Based	U.S. Based	Overseas Based
Adobe Advanced Technology Labs	Accenture Technology Labs	BMW Technology Office
Agilent Research Laboratories	Amgen	Bayer
Apple R&D	AT&T Foundry Innovation Center	Bosch Research and Technology Center North America
Applied Materials Inc.	Barnes & Noble	Elan
AMD	Bristol-Myers Squibb	Genencor, a Danisco Division
Autodesk Research	Comcast Interactive Media Labs	Hanwha Solar North America R&D Center
BioMarin	Corning	Honda R&D North America
Bio-Rad Laboratories	Ford Silicon Valley Lab	Huawei R&D
Cadence	GE Global Software Center	Mercedes-Benz Research & Development North America
Chevron	GM Research Laboratory	Nokia
Cisco Research Center	IBM Research–Almaden	Novartis Institutes for Biomedical Research
Cypress Semiconductor	Lockheed Martin Corporation Advanced Technology Center	Novo Nordisk
Dolby Laboratories Inc.	Merck	Orange Labs
Exelixis	Microsoft Research Silicon Valley	Renault-Nissan Research Center
Genentech (Roche)	Pfizer Worldwide Research & Development at Rinat	Ricoh Innovations
Gilead Science	Qualcomm MEMS Technologies	SAP Labs
Google X	SEPATON West Coast Advanced Development Office	Sennheiser Technology and Innovation Center
HP Labs, Palo Alto	Sprint Applied Research & Advanced Technology Labs	Telekom Innovation Laboratories, Deutsche Telekom
Impax Laboratories, Inc.	Texas Instruments R&D Labs	Toyota Info Technology Center
Intel Research	Verizon Application Innovation Center	Volkswagen Electronics Research Laboratory
Juniper Networks Inc.	Walmart Labs	Vodafone Xone
Lam Research Corp.		
Kaiser		
Nektar Therapeutics		
NVIDIA		
Onyx Pharmaceuticals		
Oracle Labs		
PARC, a Xerox Company		
Sandisk Corp.		
Symantec Research Labs		
Theravance, Inc.		
Varian Medical Systems		
Yahoo! Research		

Independent Laboratories and Research Institutes

Independent labs and research institutes are generally nonprofit and are self-funded through contract research and consulting. Some are outgrowths of universities or corporate labs. Like corporate labs, their goals tend to be pragmatic but are driven by customer relationships rather than a single corporate owner. In some cases, independent labs and research institutes act like consultancies that straddle the line between STEM disciplines and social science research. Some also conduct basic research and compete for federal grants.

SRI International

SRI International is a nonprofit scientific research institute that serves clients in information, engineering, pharmaceuticals, biotech, chemistry, physics, education, health and economic development. Founded as the Stanford Research Institute in 1946 by Stanford University, it separated from the university in 1970 and changed its name to SRI International in 1977. Since then, SRI has been associated with an array of game-changing innovations, including the computer mouse. Approximately 70% of its work is with government and 30% is commercial.

In 2011, SRI had revenues of $585 million and 2,100 employees. Like other Bay Area independent labs and research institutes, it has a collaborative business model, with partners such as PARC and a wide array of subcontractors including UC Berkeley. It also serves as a subcontractor to national labs.

With over 1,000 patents and patent applications, SRI has generated over 40 spin-offs, many of them high profile. This happens in two ways: internally and through incubation. A significant amount of this activity has happened through SRI's Sarnoff Institute. Noteworthy spin-offs include E*TRADE, Verbatim, the Institute for the Future, Intuitive Surgical and Siri. Four of these went on to public offerings, producing more than $25 billion in market capitalization.

To support its incubation activity, SRI maintains a venture group that places internal funds in 2–4 ventures derived from SRI technologies per year, all of them looking for potential home runs. Per venture funding is typically in the range of $400,000 and is placed only when a product is ready to be commercialized (for example, to develop a prototype). The strategy is to develop and commercialize disruptive technologies with high market potential. Potential CEOs and heads of engineering are recruited, as well as entrepreneurs-in-residence who may later become officers. Leading Bay Area venture firms such as Draper Fisher Jurvetson, Khosla Ventures, Mayfield Fund and Kleiner Perkins Caufield & Byers also participate in an advisory capacity and may later invest but are not given preferred treatment.

PARC, a Xerox Company

PARC is a research laboratory specializing in information technology R&D, both for its parent company, Xerox, and for its commercial and government partners. Created in 1970 as Xerox PARC (Palo Alto Research Center), PARC incorporated in 2002 while remaining a wholly owned subsidiary of Xerox. It was a leader in the development of laser printing, Ethernet and the modern personal computer. With four internal divisions, two hardware and two software, PARC's current areas of focus are big data, biomedical devices, clean water, cleantech and energy, content-centric networking, health and wellness, innovation services, intelligent automation, intelligent software systems, optics and optoelectronics, and printed and flexible electronics.

The laboratory has approximately 250 employees, with 80% holding a doctoral degree. As of 2012, it held 2,500 patents and is filing new patents at a rate of roughly 150 per year. Through these processes, PARC has generated over 30 start-up ventures that have received $180 million in funding and employ approximately 200 people in the region. As one example, Sol Focus, a leading supplier of concentrator photovoltaic (CPV) systems, was incubated and launched based on PARC expertise in optical system design, semiconductor materials and solid state electronics and packaging.

Electric Power Research Institute

The Electric Power Research Institute (EPRI) conducts research and development relating to the generation, delivery and use of electricity. Supported by member companies accounting for more than 90% of the electricity generated and delivered in the United States, its scientists and engineers engage both university and industry experts on issues such as energy efficiency, grid reliability, and related health and environmental concerns. Areas of inquiry include biologically mediated processes for energy production, carbon capture, materials to enhance building efficiency, and sensor systems for electrical infrastructure availability and reliability. EPRI's Technology Innovation (TI) organization particularly focuses on stimulating innovation and developing enabling technologies for adoption in a 5–10 year period. Headquartered in Palo Alto, EPRI operates nine U.S. and overseas offices.

Bay Area Research Institute

The Bay Area Research Institute (BARI) is a clinical research center located in the East Bay. Founded in 1997, its mission is to develop safer and more effective treatments for both medical and psychiatric disorders. Studies at BARI have primarily emphasized new treatments for psychiatric disorders like ADHD in adults and children, anxiety disorders, bipolar disorders, eating disorders, dementia, depression and schizophrenia, along with medical trials for influenza, insomnia, narcolepsy, osteoporosis, sleep apnea and sexual disorders.

Children's Hospital Oakland Research Institute

Children's Hospital Oakland Research Institute (CHORI) is a top 12 pediatric research center measured by National Institutes of Health (NIH) grant funding. With an annual budget of over $47 million, it is also the largest non-university pediatric medical center in the United States. CHORI conducts research on a variety of diseases that affect children as well as prenatal research on the diagnosis of mental retardation and birth defects.

Buck Institute for Research on Aging

The nation's first independent research facility devoted to the connection between aging and chronic disease, Buck Institute scientists work in an interdisciplinary environment to understand how normal aging contributes to conditions that are tied to older age such as Alzheimer's, Parkinson's, various types of cancer, strokes, heart disease, diabetes, macular degeneration and glaucoma. Research focuses not only on extending life, but on extending the quality of life in normal aging populations. Opened in March 2012 with a supporting grant from CIRM, the Institute's new regenerative medicine research building has 65,000 square feet of research space specifically focused on the application of stem cell technologies.

The Gladstone Institutes

Based in San Francisco, The Gladstone Institutes is an independent and nonprofit biomedical research organization whose mission is to better understand, prevent, treat and cure cardiovascular, viral and neurological conditions such as heart failure, HIV/AIDS and Alzheimer's disease. Its researchers study these illnesses using techniques of basic and applied science. Gladstone is also using new stem cell technologies, developed by its investigators, to advance the field of regenerative medicine. Since its founding in 1979, Gladstone has had a close partnership with the University of California, San Francisco (UCSF), where all of its principal investigators serve as faculty. The Institutes are home to approximately 450 staff members—including more than 300 scientists. Research areas where Gladstone has made an impact include cholesterol and heart disease, obesity, diabetes, infectious disease, aging, HIV pathogenesis and therapy, and neurodegenerative conditions such as Alzheimer's, Parkinson's and Huntington's diseases. The Gladstone Center for Translational Research, established in 2006, specifically works to translate basic research discoveries into patient therapies.

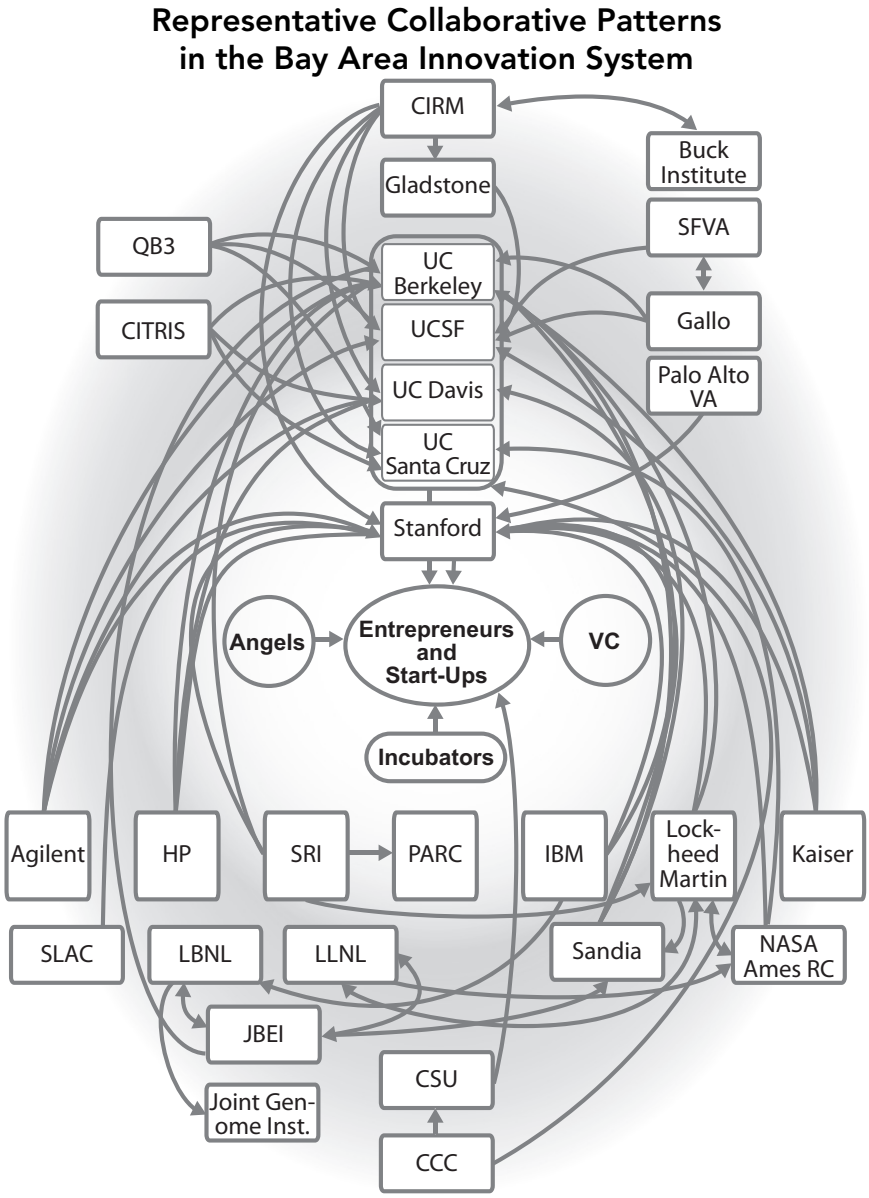
Ernest Gallo Clinic and Research Center

Like the Gladstone Institutes, the Ernest Gallo Clinic and Research Center (Gallo Center) is an independent research institute affiliated with UCSF. Originally created with funds from the Gallo family, it is now funded through the University of California, the National Institutes of Health and the Department of Defense. Gallo Center investigators have joint appointments as UCSF faculty. Located in Emeryville, the Center has a staff of 140, including 54 with PhD or other advanced scientific degrees, and an annual budget of approximately $25 million.

The Gallo Center uniquely focuses on the neuroscience of addiction, with research ranging from discovery of a cellular mechanism that underlies drug addiction (basic science) to the creation of new medications for the treatment of alcoholism (translational research). Its Institute for Molecular Neuroscience, for example, leads a Department of Defense-sponsored national network of research organizations working to develop therapies for alcoholism resulting from post-traumatic stress disorder in military personnel and veterans. Within the region, its principal collaborators are UCSF, UC Berkeley, and the San Francisco and Northern California VA research centers.

California Academy of Sciences

Founded in 1853, the California Academy of Sciences is a scientific institution with a mission that combines research and public education. Located in San Francisco's Golden Gate Park, the Academy supports a staff of seventy, with 20 PhD researchers and a $6.5 million budget. Research focuses on biodiversity and its interface with issues such as habitat loss and climate change.



Incubators and Accelerators

Incubators and accelerators play an important role in the Bay Area's innovation system by providing start-ups and young companies with affordable workspace, business support, and networking opportunities. They can also serve as qualification tools and deal flow enablers for potential venture and angel investors. Incubators are often sponsored by local governments or economic development organizations, while accelerators are usually linked more closely to the investment community and may involve a direct investment component.

Both incubators and accelerators can be corporate-sponsored or sponsored by universities.

One of the best known, Y Combinator, has incubated 380 start-ups. Twice a year, Y Combinator takes in start-ups, moves them to Silicon Valley, and gives them three months of intensive support. Participants are given a small initial investment which currently averages $18,000, and as an additional benefit they receive $150,000 in support from Russian entrepreneur Yuri Milner and "Super Angel" Ron Conway.

Another leading accelerator, Plug and Play Tech Center, offers access to more than 150 venture capital and angel investors, and to its own venture arm, Amidzad Partners. Since its founding in 2006, Plug and Play has helped start-ups access more than $750 million in venture investment. Other services include a data center, networking events, access to executives-in-residence (former consultants, industry veterans and serial entrepreneurs), legal and accounting services, assistance with sourcing teams and talent, access to university partners (Stanford, UCSF, and institutions such as MIT, Cornell and Carnegie Mellon) and 150,000 square feet of flexible workspace at three locations (Sunnyvale, Redwood City and Palo Alto). The Plug and Play International Accelerator Program also provides international start-ups with a three-month program of structured access to Silicon Valley, to help them understand their potential there.

Accelerators in the Bay Area can come in novel forms and from unexpected places. The Cleantech Open, started in 2006 in the Bay Area, uses an annual business competition to identify and support the most innovative emerging cleantech entrepreneurs and their technologies—initially in California and now nationally. Winners gain visibility and credibility and walk away with investment capital and support services (such as assistance with investor presentations, developing financial plans, and intellectual property protection). Since its inception, the Cleantech Open, which relies on a network of 1,500 volunteers, has helped nearly 600 young companies which have subsequently raised more than $660 million. Eighty percent remain active businesses.

Local Government or University-Sponsored Incubators and Accelerators
(Partial List)

- Berkeley Skydeck Accelerator
- Communications Technology Cluster
- Environmental Business Cluster
- Frugal Innovation Labs
- Mission Bay Innovation Center
- Oakland Small Business Growth Center
- QB3 East Bay Innovation Center
- QB3/PharmChem Digital Garage
- San Jose BioCenter
- San Jose Environmental Business Cluster
- Santa Clara University Global Social Benefit Incubator
- StartX
- SynBio Startup Launchpad (Singularity University with Triple Ring Technologies)
- The Garage (Berkeley)
- The Garage (UCSF)
- US Market Access Center (US MAC)

Independent, Corporate, Overseas or Multi-Sponsor Incubators and Accelerators (Partial List)

500 Startups

AngelPad

ANZA Technology Network

Bayer U.S. Innovation Center Science Hub

Berkeley Ventures

BootstrapLabs

Canadian Technology Accelerator

CTA@MissionBay (Canadian Technology Accelerator for Life Sciences)

Citrix Startup Accelerator

CoLaborator (Bayer), opening in 2012

Dogpatch Labs

Draper University of Heroes (pilot completed June 2012), opening in 2013

Fogarty Institute for Innovation

Founder Institute

Founders Den

German Silicon Valley Accelerator

Greenstart

Hatchery SOMA

Hattery Labs

Innovation Norway (San Francisco/Silicon Valley)

InnoSpring

i/o Ventures

Innovation Centre Denmark (Silicon Valley)

Innovation Endeavors Runway

Irish Innovation Center

KickLabs

mission*social

National Energy Systems Technology Incubator (i-GATE NEST)

NextSpace San Francisco

NextSpace San Jose

NextSpace Santa Cruz

Center for Therapeutic Innovation (Pfizer)

Plug and Play Tech Center

Public Media Accelerator

Renaissance Entrepreneurship Center

RocketSpace

Rock Health

SCORE

Siemens Technology-To-Business Center

Springworks

StartupHouse

swissnex San Francisco

TechBA Silicon Valley

Teens in Tech Incubator

The Foundry, LLC

WeWork SF–SOMA

Y Combinator

Zero1 Garage

Investment Capital

The Bay Area is home to more than 300 firms that invest in emerging companies. These are primarily venture capital firms but also include private equity. This figure does not include angel investors. The investment community is highly diverse, including large firms that invest in a variety of sectors (such as New Enterprise Associates), small firms that invest in early-stage companies (such as X/Seed Capital) and firms that specialize in specific industry sectors (such as Burrill & Company for biotech and VantagePoint Capital Partners for cleantech).

Venture Capital Firms

Venture capital (VC) firms are standalone partnerships (not affiliated with a larger corporate or government organization) whose sole aim is to commercialize solutions to problems and generate financial return on investment. This is distinct from corporate or government affiliated venture firms (often called "strategics"), whose purpose is the advancement of larger corporate or government objectives by way of helping their business units develop better or supporting products and services.

Venture capital firms are the leading instrument for funding new ventures in the Bay Area innovation system. Over the past decade the Bay Area has, on average, received 36% of national venture capital investment and 16% of global venture capital investment; in Q4-2011 the region received 46% of U.S. VC investment.

Largest Venture Capital Firms in the Bay Area

(S.F. Business Times 2012 Book of Lists)

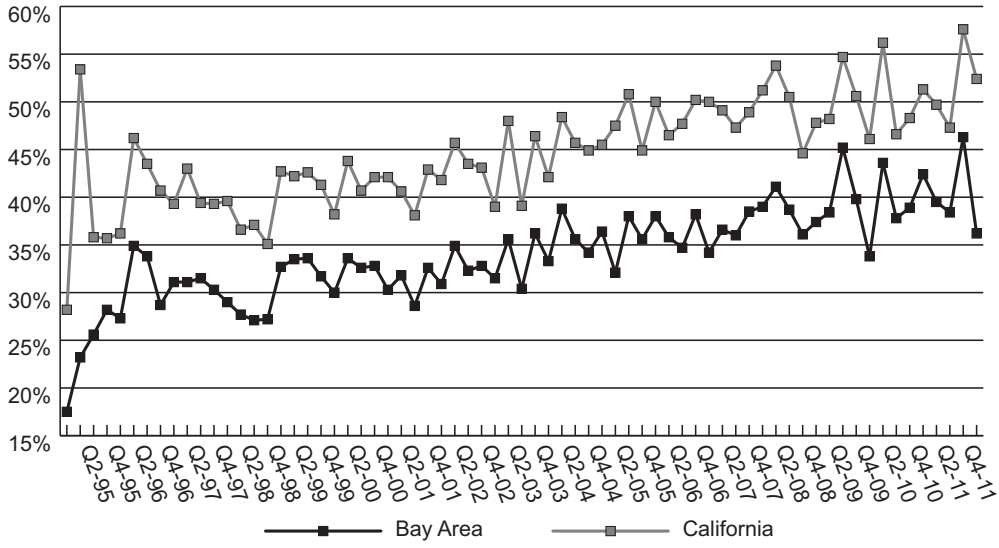
1. TA Associates
2. New Enterprise Associates
3. Summit Partners
4. VantagePoint Capital Partners
5. Battery Ventures
6. Norwest Venture Partners
7. Menlo Ventures
8. Weston Presidio
9. U.S. Venture Partners
10. Canaan Partners
11. Institutional Venture Partners
12. InterWest Partners
13. Venrock
14. Foundation Capital
15. DCM
16. SV Life Sciences
17. Walden International
18. Advanced Technology Ventures
19. August Capital
20. CMEA Capital
21. Sofinnova Ventures
22. Focus Ventures
23. Partech International
24. Crosslink Capital
25. Rho Capital Partners

As of January 2011, the top 25 venture capital firms in the Bay Area have capital under management totaling $87.75 billion.

(See also Appendix: *Venture Capital and Private Equity Firms in the Bay Area*.)

The Bay Area's share of national venture capital funding reached a high of 46% in the fourth quarter of 2011.

Bay Area and California shares of U.S. venture capital
Q1-1995 to Q1-2012



SOURCE: PricewaterhouseCoopers MoneyTree

The Bay Area's share of global investment has been constant in recent years, even as the U.S. share has fallen. This suggests that the Bay Area remains a highly attractive place in which to invest based on the entrepreneurial and technology opportunities it presents. It is not uncommon for enterprising new firms to relocate to the Bay Area to gain better access to this funding. VC firms work closely with the research community in their search for new ideas and talent. The Bay Area absorbed $11.2 billion in venture funding in 2011, across 1,077 deals.

VC firms also maintain active relationships with corporations to nurture entrepreneurial culture, but also to develop distribution channels and facilitate acquisition of these start-ups once they have achieved profitability and scale. For instance, in 2011 four top-ranked Bay Area VC firms participated in the GE-led Ecomagination Challenge, which allocated $200 million to the search for cleantech solutions focused on energy generation, efficiency, smart grids and smart homes. The Challenge evaluated 100,000 submissions from around the world, leading to 5 winners and 10 industrial partnerships. GE says that at least 100 products have been brought to market since the inception of the Ecomagination Challenge in 2010.

Angel Investors

Angel investors and super-angel investors are wealthy individuals or groups of individuals who fund entrepreneurs at the pre-VC stage. The dollar amounts invested are smaller than VC amounts and are primarily directed to start-ups and early-stage firms. Facilitated by a number of organizations and forums in the Bay Area, angel investors congregate to evaluate new ideas, often through competitions for aspiring entrepreneurs.

Private Equity

Private equity firms can also play an import role by providing expansion or restructuring capital through equity and debt instruments. Typically their investments are at a higher dollar level than VC investments. Particularly in the Bay Area, private equity increasingly partners with venture capital in capital-intensive fields such as cleantech, where the need for manufacturing and production facilities requires investment on a larger scale than VC alone can typically support. Private equity is distinct from buy-out funds, which acquire underperforming, mature corporations in order to restructure them.

Angel Investor Organizations in the Bay Area (Partial List)

Angels' Forum
Band of Angels
Golden Gate Angels
HBS Angels, Northern California
Investors' Circle
Keiretsu Forum
Life Science Angels Inc.
North Bay Angels
Sand Hill Angels
Silicom Ventures
Tech Coast Angels
TiE Angels
Tribe of Angels
US Angel Investors

Together, the nine most active angel investors in the Bay Area invested $21.6 million in 2011.

Bay Area Based Corporate Venture Capital Units (Partial List)

BP
Chevron Technology Ventures
Citi Ventures (Citigroup)
Comcast Ventures
Google
Intel Venture Capital
SAP Ventures
Siemens Venture Capital
Swisscom Ventures
T-Ventures, Deutsche Telekom
Vodafone Ventures

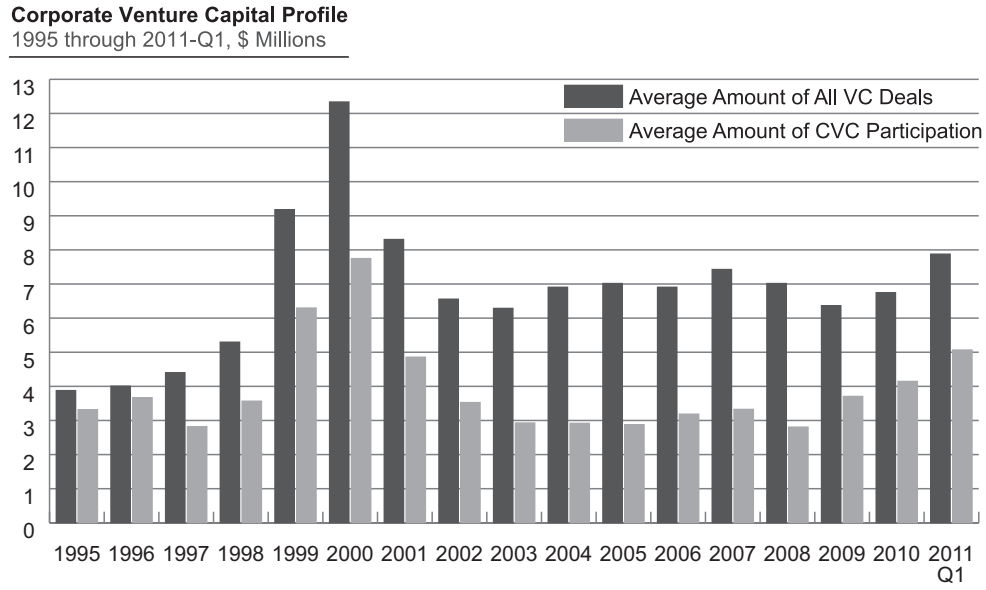
In 2011, corporate venture firms invested in 214 deals in 196 Bay Area companies, with total investment valued at $3.26 billion.[18]

[18] Deborah Gage, "Corporations Refocus on Venture Investing," *Wall Street Journal*, March 22, 2012.

Corporate Venture Capital Units

Most corporate venture firms focus on the identification and support of emerging companies in their industries that produce complementary products or may be candidates for future acquisition. For example, IBM and Intel have active Bay Area teams, and Citi's venture arm focuses on scalable, disruptive technologies relating to the financial services industry. Corporate venture firms may also provide equipment and consulting advice to start-ups with complementary technologies. Corporate venture capitalists (CVCs) tend to make smaller investments than independent VCs, in part because (in addition to financial return) they have strategic objectives that can be accomplished by putting in less money.

Corporate Venture Capital Profile, 1995 through 2011–Q1, $ Millions

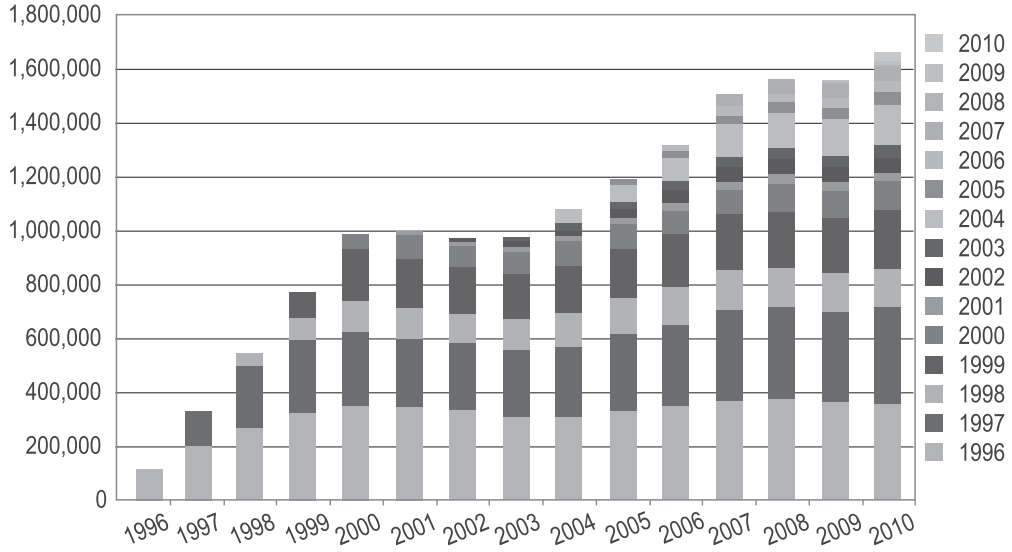


SOURCE: PricewaterhouseCoopers/National Venture Capital Association MoneyTree™ Report; data from Thomson Reuters

IPO Effects and Other Financing Mechanisms

Venture-backed companies that go public though IPOs are a significant source of revenue generation and employment nationally, but particularly in the Bay Area and California. From 1996 through 2010, the 2,776 domestic U.S. companies that went public collectively employed more than 5 million people before and 7.3 million people after going public. This increase in post-IPO employment works out to 822 jobs added per firm. Those companies collectively had $1.3 trillion in annual sales before going public and $2.58 trillion after (FY 2010), a 96% increase. Most of this activity has been concentrated in a handful of states. California is home to 46% of all IPOs by emerging growth companies, followed by Massachusetts, New York and Texas. Among metropolitan regions, the San Francisco Bay Area has the highest concentration (348 or 35.7% of all venture-backed IPOs nationally) followed by Boston. These measures of economic impact do not count the secondary effects of firms such as eBay and Google that have impacts extending far beyond their internal performance and have been responsible for the reorganization of entire sectors and the creation of new ecosystems of businesses building on their infrastructure.[19]

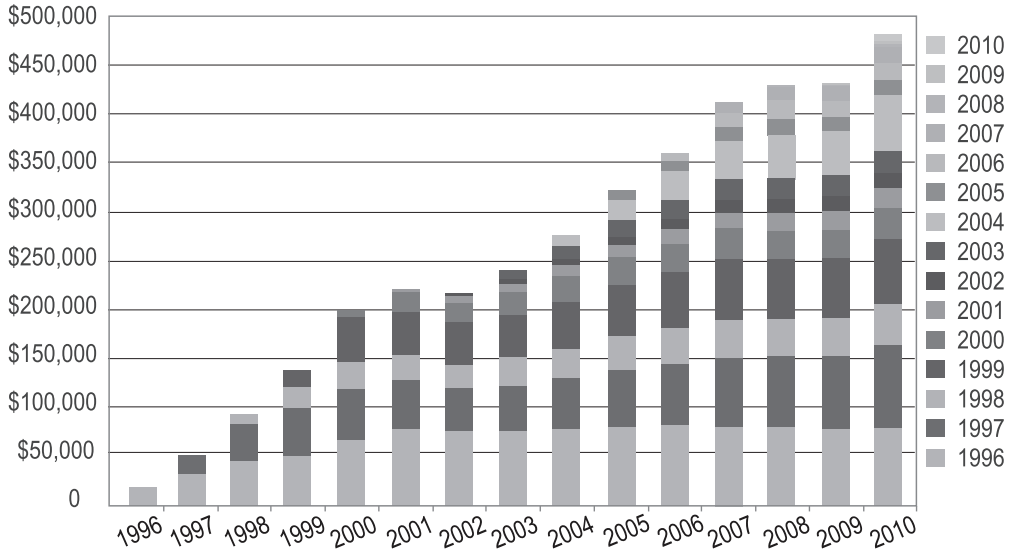
Annual Employment by Cohort Year, Emerging Growth Company IPOs, 1996–2010



SOURCE: Ewing Marion Kauffman Foundation

[19] Ewing Marion Kauffman Foundation, *Post-IPO Employment and Revenue Growth for U.S. IPOs June 1996-2010* (Kansas City: Kauffman Foundation, 2012).

Annual Revenues for All Emerging Growth Company IPOs by Cohort in Millions of 2011 Dollars, 1996–2010



Explanation: The single bar in 1996 is the 1996 revenues for all firms that had IPOs in 1996. In 1997, the lower bar represents the revenue of the 1996 cohort in 1997, and the upper bar represents the 1997 cohort's revenue in 1997, etc.

SOURCE: Ewing Marion Kauffman Foundation

More recently, new community- or crowd-based financing mechanisms are gaining a following. Peer-to-peer entities, such as Prosper, allow individuals to pool their money. These mechanisms have roots in the micro-finance model pioneered by Bangladesh-based Grameen Bank and have particular appeal in the social entrepreneurship arena.

Banks and Debt Finance

Both specialized and larger banks also play a role by providing debt capital to young companies. In the Bay Area many banks, including Bank of America, Mechanics Bank, New Resource Bank, Silicon Valley Bank and Wells Fargo, have extensive experience supporting the small business community and have accumulated specialized knowledge about entrepreneurial business models and their requirements.

Silicon Valley Bank

With $20 billion in assets and more than 1,500 employees, Silicon Valley Bank (SVB) provides commercial, international and private banking services through 34 locations worldwide. Headquartered in Silicon Valley, SVB is the only global bank dedicated to the innovation sector, with banking staff specializing in sectors such as software, Internet, hardware, life sciences, cleantech and venture capital. Fifty percent of all venture-backed technology and life sciences companies in the U.S. bank with SVB. Its services go beyond traditional banking to include assistance designed to increase the probability of its clients' success. The SVB Accelerator, for example, offers programs to help entrepreneurs raise funding, connect with business partners, and access banking services tailored to entrepreneurial needs.

Government Support Frameworks

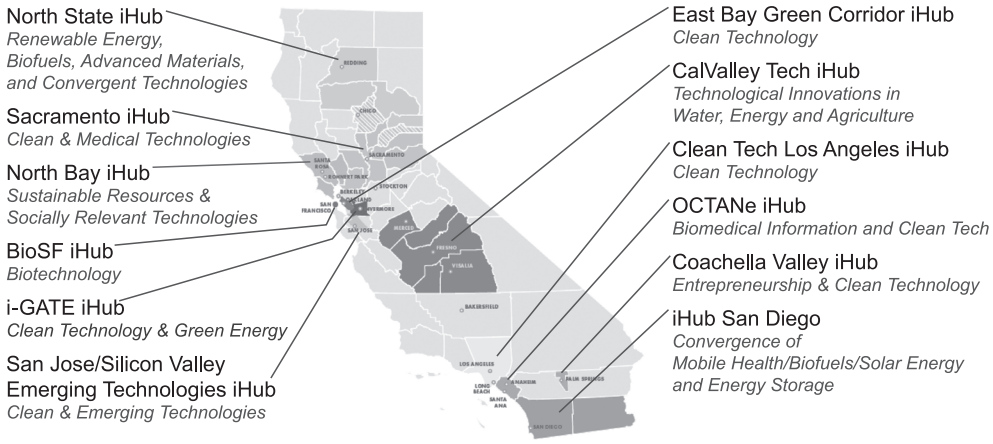
Federal government support for science and innovation in the Bay Area comes not just through research grants and research at federal institutions, but also through support for targeted collaboration activity, such as the Bay Area Photovoltaic Consortium. Supported by the U.S. Department of Energy in 2011 with $25 million in funding spread over five years (2011–2016), the Consortium is part of the national SunShot Photovoltaic Manufacturing Initiative, which supports industry-relevant R&D to reduce manufacturing costs, improve device performance, and lower the installed cost of solar cell modules. Led by Stanford and UC Berkeley, but engaging universities nationwide, the Consortium is governed by a board composed of co-directors from Stanford and UC Berkeley, two representatives from other universities and four representatives from industry.

In contrast, the State of California has relatively few economic development programs to support innovation. One is the newly created system of Innovation Hubs (iHubs)—designated innovation zones designed to integrate and leverage local innovation assets such as research parks, technology incubators, universities, federal laboratories, business organizations, entrepreneurs, VC firms, and workforce and economic development agencies.

The Bay Area hosts five of California's 12 iHubs: North Bay iHub, BioSF iHub (Greater Mission Bay Area iHub), San Jose/Silicon Valley Emerging Technologies iHub, i-GATE (Green Advanced Transportation Excellence) iHub, and East Bay Green Corridor iHub. iHubs may provide infrastructure, such as incubation space, networking, training, management assistance, financial resources, and support networks for new and emerging companies.

California's iHubs leverage assets to stimulate partnerships, economic development and job creation around specific research clusters.

California Innovation Hubs
and their research clusters



SOURCE: Governor's Office of Business and Economic Development

While the initiative is still fairly new, anecdotal evidence suggests that the concept of weaving disparate actors and institutions more closely together through professional economic development offices yields tangible benefits.

3.
A Global Marketplace of Ideas

The Bay Area enjoys a diverse and highly evolved innovation ecosystem of actors that conduct research and ventures and supporting actors that take the results to market. A critical element in this value chain, and key to its success, is the research and business culture in which the players interact, identify problems and commercialize solutions. These processes rest on two critical elements: (1) mobility, permeability and flexibility, and (2) interconnected networks.

Mobility, Permeability and Flexibility

An innovation-focused region must be open to the migration of talent into, out of and within it. Factors such as immigration policy (for access to global talent) and convening spaces (that enable the mingling and interaction of talent and ideas across geographic and organizational boundaries) are critical. So is a mindset that welcomes the continuous exchange of information and ideas. This mindset explains why innovators who come to the Bay Area often do best if they view their investment of time, effort and resources not as an investment in one particular venture, but in a series of ventures and enterprise relationships over the course of a career. This enables their full participation in the innovation ecosystem and their movement between companies and organizations as ideas and teams combine and recombine.

The Bay Area innovation system facilitates this mindset with flexible structures in which organizations are permeable to mobile and creative individuals. This fluidity, which enables its components to creatively interact, is at the heart of the region's "innovation culture."

This report focuses on the structural components of the Bay Area's innovation system and does not directly address its broader cultural context. However, recent studies by the Bay Area Council Economic Institute have explored the business and cultural dynamics of the region's Chinese-American and Indian-American communities, two prominent sources of regional and global innovation that constitute a major element in the Bay Area's large community of entrepreneurs. The Institute has also explored the culture of innovation inside leading technology companies, finding distinct business and management practices that set them apart from national and global competitors. These studies, which are accessible on the Economic Institute's website (www.bayareaeconomy.org), confirm other research suggesting that business innovation is not necessarily determined by the level of R&D spending, but can also derive from the innovation culture within companies.

In the end, a culture that encourages mobility, creativity and risk taking, and is accepting of failure, is critical to the development of new business models, creative partnerships and the development of breakthrough technologies. New groups are constantly forming to explore opportunities and may dissolve just as quickly. As seen in the Bay Area, these communities form when an area's cultural environment enables flexible association, the "colliding" of ideas and continuous learning.[20]

Interconnected Networks

Networks facilitate these flows and create long-term trust between actors. Networks can be effective in transcending organizational boundaries and as investment channels.

The diversity of networks and their members in the Bay Area is dramatic. In contrast to regions that rely heavily on a single technology or area of expertise, the diversity of domains and technological expertise within the region—from IT to nanotechnology, biotechnology, cleantech and aerospace—enhances opportunities for cross-disciplinary fertilization and innovation. Networks play a vital role in this process, enabling the testing of ideas and the combination of knowledge across disciplines.

Bay Area networks come in different forms, on a continuum of informal to formal. Formal networks are based on relationships with more or less clearly defined roles, goals and agendas and are typically seen in functional, business and industry associations such as BASIC (the Bay Area Science and Innovation Consortium) and BayBio, the regional biotechnology industry association. Informal networks are looser affiliations of individuals and organizations based on overlapping sector or professional interests.

Like their more formal counterparts, informal networks provide their members with access to information, but more importantly they provide access to professional contacts through structured programs and social and professional events. Examples include SV Forum, the Technology Salon, the Churchill Club, the Western Association of Venture Capital, the Telecom Council of Silicon Valley, and Mobile Mondays, as well as national or ethnically-focused associations such as Digital Moose Lounge (Canada), TiE (The Indus Entrepreneurs), IVCA (the Indian Private Equity & Venture Capital Association), EPPIC (Enterprising Pharmaceutical Professionals from the Indian Sub-Continent), Silicon Valley Indian Professionals Association, Asian-American Multi-Technology Association (AAMA), the Chinese Institute of Engineers (Bay Area), the Monte Jade Science and Technology Association (West Coast), and the Hua Yuan

[20] Steven Berlin Johnson, *Where Good Ideas Come From: The Natural History of Innovation* (Riverhead Books, 2012).

Science and Technology Association (HYSTA). A number of these associations have worldwide chapters.

The Bay Area's Chinese and Indian communities have been particularly effective in organizing professionally-based networking organizations focused on technology. Perhaps the best example is TiE (The Indus Entrepreneurs), which grew from an informal conversation in a Silicon Valley hotel in 1992 to become the world's largest entrepreneurial organization, with 1,800 charter members, 11,000 general members, global headquarters in Santa Clara (TiE Silicon Valley) and 53 chapters in 12 countries. Since its founding, TiE's principal focus has been the support and mentoring of entrepreneurs, through conferences and events, an annual job fair, mentorship clinics, training by senior members in business strategy and management (the TiE Institute) and introductions to investors.

By greasing the skids of interpersonal and interorganizational relationships and transactions, these networks bridge the research-to-commercialization value chain and touch every point of the innovation system map.

The region's innovation culture is often informal. Entrepreneurs have many role models who have successfully (or unsuccessfully) started companies and are willing to share their experience. Innovation and entrepreneurship can ultimately be traced to the mindset of individuals. This less tangible but essential element is often overlooked in conventional economic development strategies and in overseas government initiatives designed to promote innovation and technology development. The international centers that result from such initiatives are often monolithic, and by undervaluing interaction and the value of different perspectives, they may find it more difficult to filter and advance ideas. Even competitors in the Bay Area talk to each other, and the quick qualification of potential partners through informal networks can be a highly effective multiplier, speeding the combination and alignment of resources and assets.

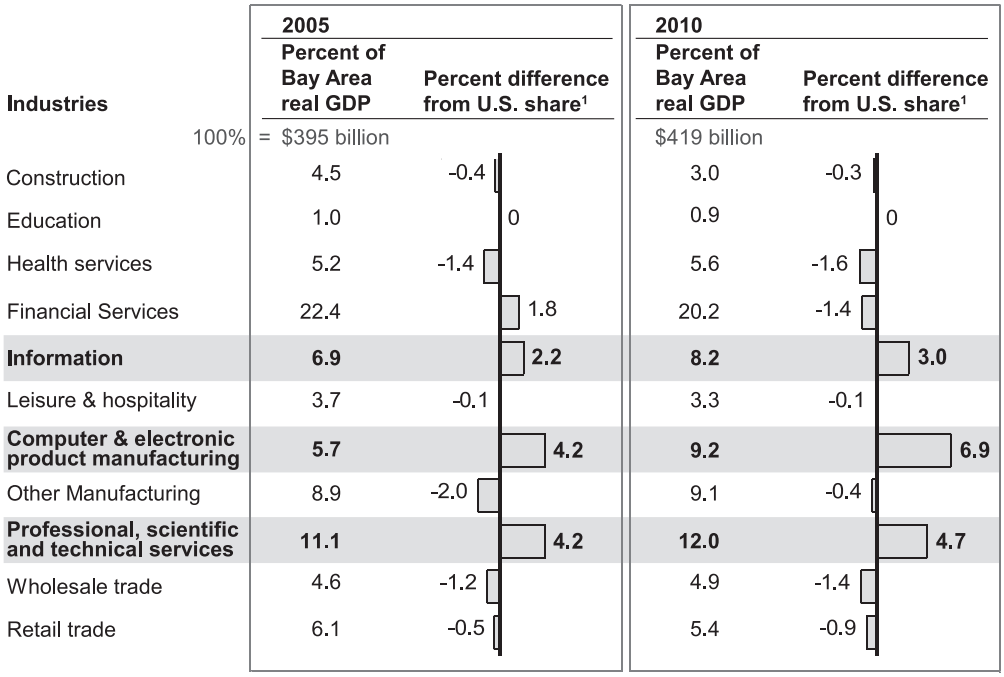

BAY AREA COUNCIL
BASIC
BAY AREA SCIENCE &
INNOVATION CONSORTIUM

4. Regional, National and Global Economic Impacts of the Model

The Bay Area innovation system delivers tangible economic benefits that, while concentrated in the region, are felt in California, the U.S. and globally.

Three innovation-led sectors—information, computer and electronic manufacturing, and professional and scientific services—have driven recent economic growth: while these sectors make up approximately 30% of the regional economy, they account for 100% of its growth since 2005. The 30% of the Bay Area's GDP that these sectors represent compares to 15% for the U.S. economy as a whole.

The Bay Area is becoming increasingly specialized compared to the U.S. in computer manufacturing, information, and professional services.

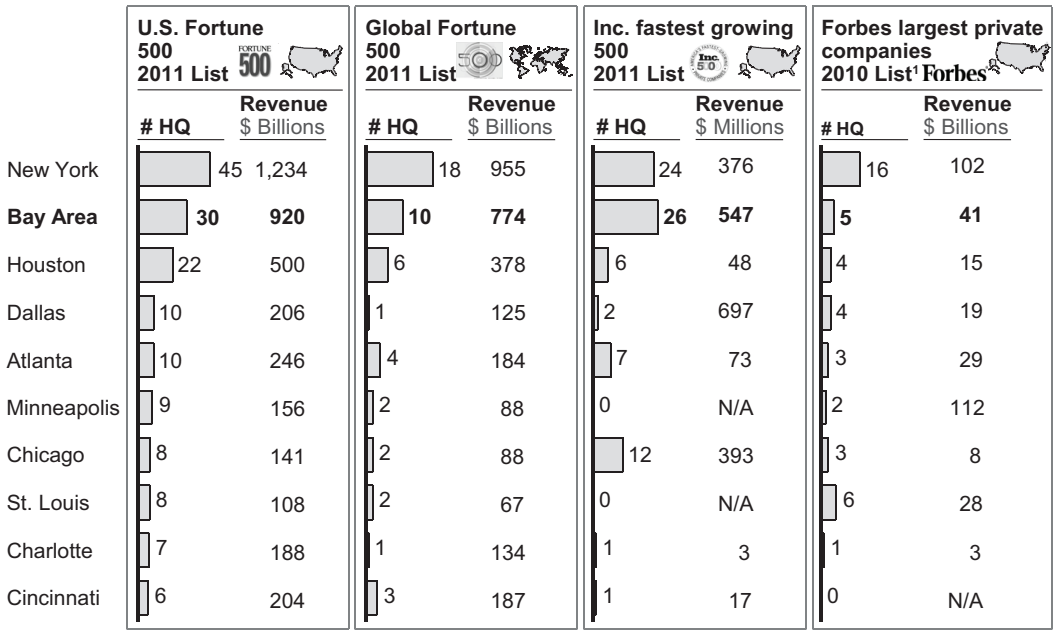


1 A positive figure indicates that the Bay Area has a greater degree of its GDP concentrated in the industry than does the U.S. overall

SOURCE: Moody's Economy.com; Bay Area Council Economic Institute and McKinsey & Company analysis

While not all Bay Area companies are technology companies—the region's industry mix is in fact very diverse—many of the largest and fastest growing global technology companies are based in the region, with the greatest concentration in Silicon Valley. Significantly, the Valley claims the world's leading device maker (Apple), the world's leading service company (Google), the world's leading social media site (Facebook), the world's leading chip maker (Intel), the world's leading networking equipment maker (Cisco), and the world's second largest software and largest relational database company (Oracle). Even companies in traditional sectors such as Chevron are major developers and users of technology, with substantial RD&D (research, development and deployment) programs.

Many of the largest and fastest growing global companies are based in the Bay Area.

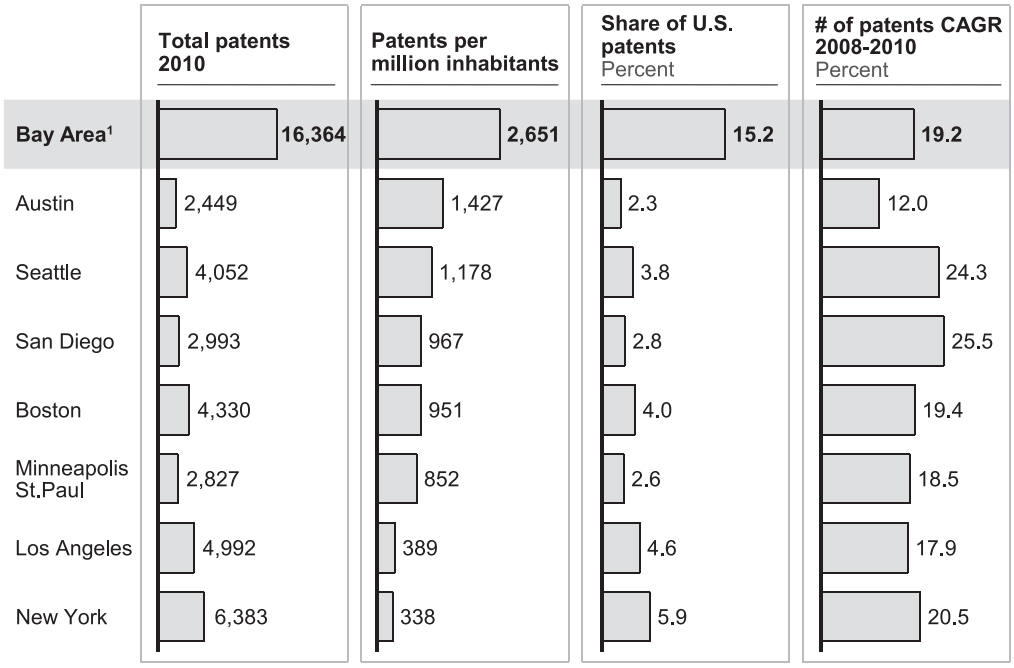


1 Forbes largest private companies list comprises 223 companies; revenues for a number of Forbes largest private companies are calculated by using Forbes estimate or company provided estimate

SOURCE: Fortune Magazine; Inc. 500; Forbes; Bay Area Council Economic Institute and McKinsey & Company analysis

One measure of the region's innovation output is patents. In 2010, the Bay Area had over 2,600 patents per million inhabitants, far more than second place Austin with approximately 1,400, or third place Seattle with approximately 1,200. With only 2.3% of the nation's population, the Bay Area generates 15.2% of all U.S. patents—a number that in recent years has grown 20% annually.

The Bay Area remains at the head of its peer regions in terms of patents granted.

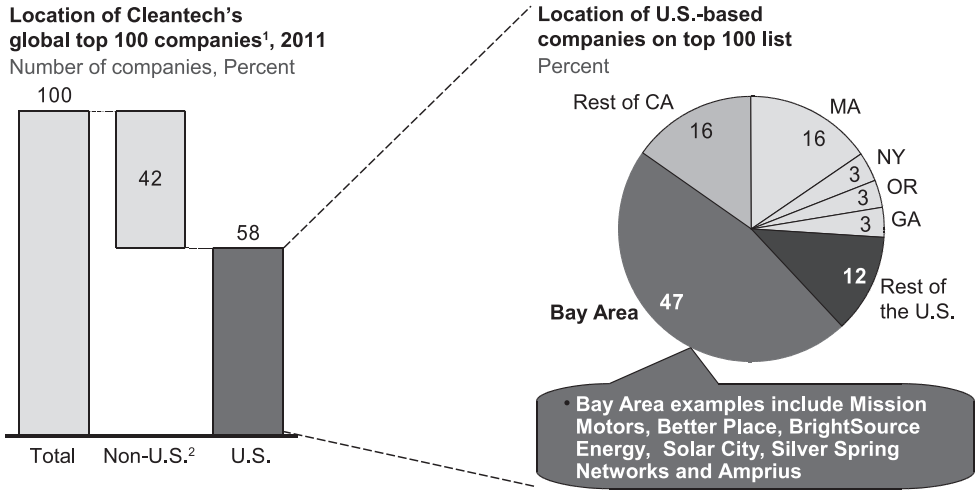


1 Data for San Francisco and San Jose MSAs

SOURCE: U.S. Patent and Trademark Office; U.S. Census Bureau; Bay Area Council Economic Institute and McKinsey & Company analysis

The economic effects of the Bay Area innovation system can be particularly seen in two emerging sectors that exemplify the fluidity with which regional assets are combined and redeployed to address and create new market opportunities. Nearly half of the top 100 private cleantech companies in the U.S. and 7 of the top 10 social media companies in the country are located in the region.

Nearly half of the Cleantech Group's 100 top private cleantech companies in the U.S. are located in the Bay Area.



1 These are the 100 cleantech companies that are the most likely to make the most significant market impact over the next 5-10 years. Companies must be independent, for-profit, and not be listed in any major stock exchange.

2 Non-U.S. companies (and number of companies) include: UK (9), Germany (5), Israel (4), Netherlands (4), Canada (3), China (3), France (3), Australia (2), Denmark (2), Sweden (2), and one company each in Belgium, Finland, India, Norway, and New Zealand.

SOURCE: Cleantech Group's global top 100 cleantech companies, 2011; Bay Area Council Economic Institute and McKinsey & Company analysis

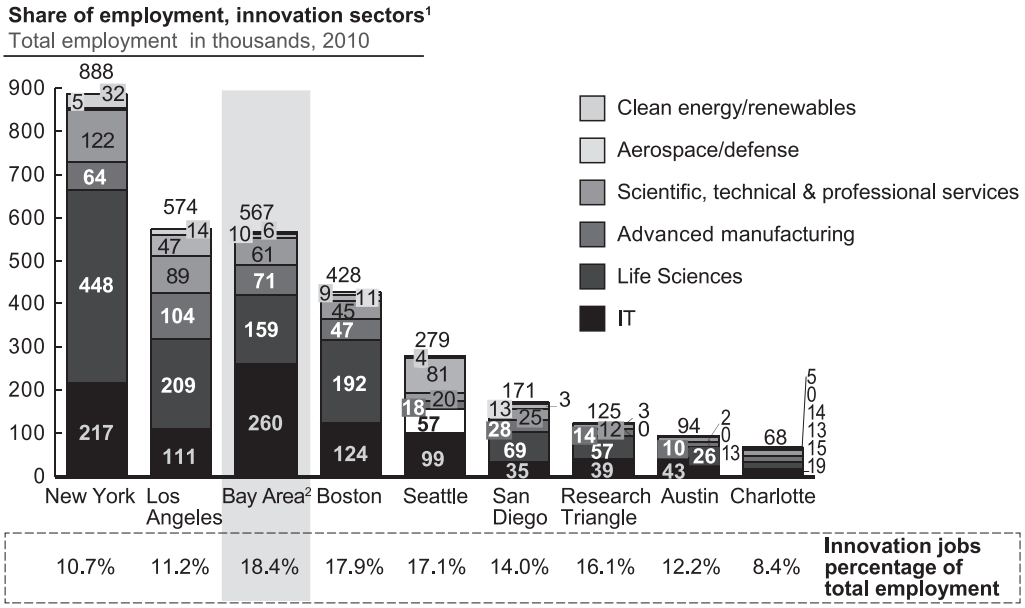
Seven out of the top 10 social media companies are in the Bay Area.

Company	HQ	Market cap 2010 U.S. $ billion	Revenue FY 2011 U.S. $ million	Employees	Users Millions
facebook	Palo Alto	84.0	4,270	2000+	800
YouTube	San Bruno	N/A	1,600	N/A	500
twitter	San Francisco	4.0	140	600	200
zynga	San Francisco	9.0	1,000	1300	195
LinkedIn	Mountain View	8.0	140	1000	116
flickr	Sunnyvale	N/A	N/A	N/A	51
yelp	San Francisco	0.2	30**	750	50
GROUPON	Chicago	15.7	313	7000+	35
	Santa Monica	0.04*	109	200	30
foursquare	New York	0.6	N/A	75	10

* 2011 Acquisition value
** 2009 data
SOURCE: Hoover's, eMarketer, Tech Crunch, Business Insider, press search

This business growth is reflected in and supported by the region's employment base, which has the highest share of innovation-related jobs of any region in the country.

Innovation jobs represent a larger share of jobs in the Bay Area than anywhere else in the country.



1 Innovation sectors are defined as industry NAICS code categories with higher than average U.S. productivity, preferably with high growth and capacity for intellectual or scientific progress

2 Bay Area includes five MSAs: San Jose, San Francisco, Napa, Santa Rosa and Vallejo; Research Triangle includes Durham and Raleigh MSAs

SOURCE: Moody's Analytics; BLS; Bay Area Council Economic Institute and McKinsey & Company analysis

In this context, it is important to note the role that highly educated immigrants have played and continue to play in supporting the region's innovation engine. UC Berkeley visiting scholar Vivek Wadhwa[21] estimates that between 1995 and 2005, one quarter of all technology and engineering start-ups in the U.S. were created by immigrants. In Silicon Valley the number was 52%. While the Bay Area has attracted entrepreneurial immigrants from around the world, the greatest proportion of start-ups has been created by immigrants from India and greater China, who heavily populate Bay Area universities' graduate departments in physics and engineering, account for a high proportion of the staff of corporate and other research laboratories, and account for a disproportionately large share of the Bay Area's entrepreneurial activity.

[21] Vivek Wadhwa, Vice President of Academics & Innovation, Singularity University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5.
The Model Under Pressure: What Is Changing?

The Bay Area Model in the Context of the Evolving Global Innovation Economy

While the Bay Area innovation system and its elements have performed well over the past five decades, the global innovation economy in which it operates has evolved. Where a group of innovation centers in industrialized countries once dominated the landscape, a number of emerging markets, most notably in Asia, have advanced economically and have also developed significant innovation centers and programs. This is leading to a more geographically dispersed web of multiple global innovation centers.

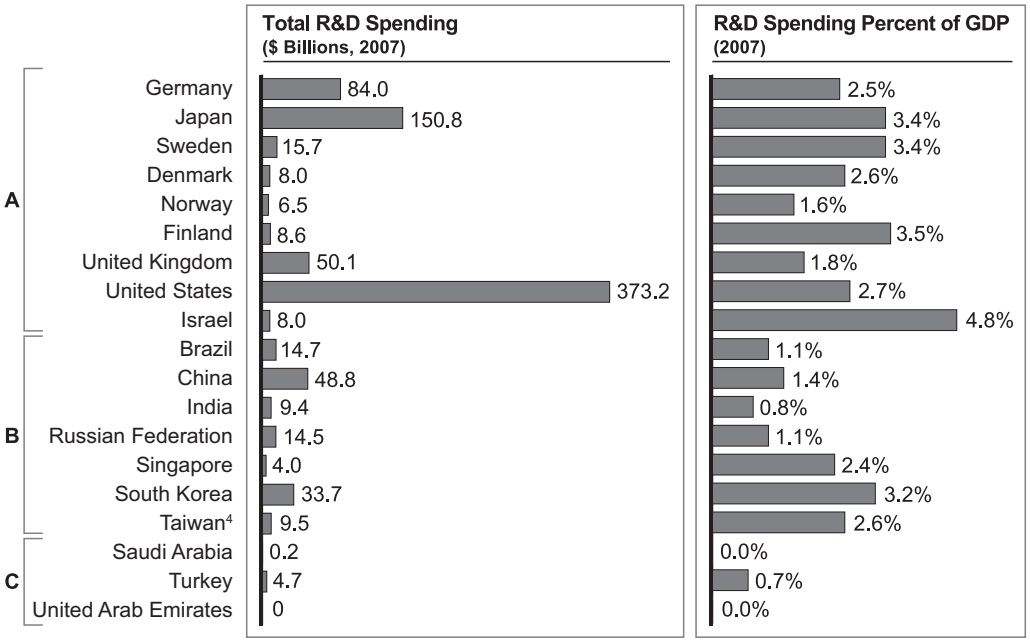
Cleantech, one area where the Bay Area has specialized, offers an example of the globally distributed nature of innovation. The Cleantech Group's Global Cleantech Innovation Index 2012 documents that new companies and industry leaders are developing rapidly in a range of global centers. North America and Europe (led by Denmark and Israel) are still the primary contributors to the development of innovation-based, entrepreneurial cleantech companies, but the Asia-Pacific region is close behind. While countries such as China and India are not yet creating innovative cleantech companies in large numbers, they are already major centers of manufacturing production, with growing markets, supportive governments and large amounts of capital available for investment.[22] This could shift the center of gravity in the sector over time.

The innovation prowess of both advanced and emerging economies is rising in three domains that are traditional Bay Area strongholds: information and communications technology (ICT), cleantech and life sciences.

[22] The Cleantech Group, *Coming Clean: The Global Cleantech Innovation Index 2012* (London/San Francisco: The Cleantech Group, 2012).

Comparisons of R&D spending totals and percent of GDP across economies indicate the global dispersion of innovation in ICT, cleantech and life sciences.

R&D spending in 3 sectors only: ICT[1], cleantech[2], and life sciences[3]
(A) Advanced innovation economies
(B) Emerging economies transitioning from low-cost manufacturing and assembly to innovation
(C) Developing economies leapfrogging from a commodities- to an innovation-based economy



1 ISIC categories: Communication, TV, and radio equipment; Post and telecommunications; Computer and related activities
2 ISIC categories: Recycling; Electricity, gas, and water
3 ISIC category: Pharmaceuticals
4 Taiwan data for 2006
SOURCE: World Bank, OECD, WIPO

What is driving this transition to a more globally dispersed innovation economy? Three factors stand out.

(1) National Macroeconomic Policies

As part of the evolution of the economies of developing countries from agrarian and commodity bases to higher value added goods and services, many of these countries shifted from protectionist import substitution to more open export oriented models—as part of an overall move to liberalize trade and investment in goods and services. One result was an increase in cross-border foreign direct investment (FDI) and the accompanying knowledge transfer from industrialized country multinationals to their host country partners. At the same time, forward-looking technocrats in some host countries—most notably China, India, Singapore, South Korea, Taiwan and Israel—instituted progressive initiatives in education, industrial development and R&D that drove indigenous capabilities toward higher value ground. The percentage

of school enrollment in tertiary education, for example, jumped from 7% to 26% in China between 1999 and 2009. Turkey and Brazil also showed strong increases over this period from 23% to 46% and from 15% to 36%, respectively.

(2) Information and Communications Technology

Successive waves of ICT and Internet technologies over the past 25 years have enabled the knowledge transfer described above as well as the global proliferation of business transactions and information flows. In particular, the global redistribution of services such as software development has been enabled by the ability to transmit information in real time to and from anywhere on the globe. More recently, the confluence of social media, networking and cloud computing, arguably led by developments in the Bay Area, has facilitated even deeper collaboration and funding across borders, not just for large corporations, but for a new generation of start-ups. In other words, by transforming processes within and between enterprises across borders, information technology has acted to level the playing field between industrialized and developing economies.

This global shift can be observed in the convergence of high-technology exports as a share of manufactured exports from developed and emerging economies. While this share declined from 34% to 20% in the United States between 2000 and 2010, in the same period it increased from 19% to 28% in China.

(3) Sovereign Finance

More recently, the emergence of new models of state-supported capitalism and sovereign finance, particularly in Asia, have also helped drive the development of more globally distributed capabilities. Sovereign finance comes in multiple forms, including Sovereign Wealth Funds (SWFs). These are private equity funds run by private sector management but investing public money. With the rise of a number of Asian and some Middle Eastern economies, billions of dollars have flowed into their SWFs. In 2010, 21 of 30 SWFs executed 172 investments valued at U.S.$52.7 billion. This represents an increase of more than 50% in deal volume from 2009. Their investment focus has largely been on financial services that enable local commercial environments, as well as commodities, but it has recently been shifting toward smaller VC-type investments.[23] Examples include the cleantech company Fisker Automotive, whose Series C financing round that raised $65 million in 2008 was led by an affiliate of the Qatar Investment Authority.

[23] Monitor Group, *Braving the New World: Sovereign Wealth Fund Investment in the Uncertain Times of 2010* (Cambridge: Monitor Group, 2011).

The jury is still out on whether this model of state-supported capitalism can be successful in the long term. The question is whether sovereign finance can yield sufficiently large returns to compensate for the risk of inefficient capital allocation (since much of this investment is likely to be unproductive). But for the near term at least, sovereign finance will be an economic factor in both developed and emerging economies.

Emerging Global Innovation Centers

Many of these factors have been described in seminal works, such as Thomas Friedman's international bestseller *The World Is Flat*, where he laid out his theory that location is increasingly irrelevant in global business. However, this global flattening is only one part of a more complex picture. Another commentator, Richard Florida, posed this view in *The Atlantic Monthly* stating, "By almost any measure the international economic landscape is not at all flat. On the contrary, our world is amazingly 'spiky'," [24] with innovation and economic growth concentrated a cluster of global business centers characterized by their appeal to educated, mobile and creative workers.

As a result of this dispersal of talent and capability, manufacturing for local markets—particularly when they are large such as China, India and Brazil—now supports applied research and development that leads to customized products and services to address local needs. Different innovation hubs have emerged based on distinct assets and capabilities, often with significant global connections. Knowledge that is generated in one R&D institution may be circulated between different institutions in global R&D networks for local and sometimes global adaptation. This dynamic drives globally distributed innovation.

Together, these factors have supported the emergence of new innovation centers throughout the world. McKinsey & Company has identified 22 Silicon Valley-like Chinese innovation hubs in biotech and life sciences alone, as well as other innovation centers focusing on manufacturing excellence in semiconductors.[25] While Europe, Japan and the United States maintain strong leadership positions in R&D with 3,525, 5,409 and 4,673 researchers per one million people respectively in 2007 (the most recent year for which data is available), from 1998 to 2007 South Korea more than doubled its number from 2,034 to 4,672. Over the same period, China experienced an increase from 389 to 1,077, and Singapore from 3,030 to 5,955.[26]

[24] Richard Florida, "The World Is Spiky," *The Atlantic Monthly*, October 2005.

[25] Gordon Orr and Erik Roth, "A CEO's Guide to Innovation in China," McKinsey Quarterly, February 2012.

[26] The World Bank, "Researchers in R&D (per million people)," Data: Indicators: Science & Technology, http://data.worldbank.org/indicator/SP.POP.SCIE.RD.P6 (accessed June 15, 2012).

From 1999–2009, the compound annual growth rate of Chinese university R&D expenditures was 22%—a rate higher than its compound GDP growth and higher than that of the U.S. in the immediate post-Sputnik era. Reflecting this, there has been a dramatic expansion in the amount of published research by Chinese authors in scientific journals—from 3% of the amount by U.S. authors in 1989 to 30% in 2008. Even though in terms of citations by other scientists, the U.S. and United Kingdom continue to enjoy enormous leads, China enjoys growing strength in specific fields such as nanotechnology.[27] While the quantity of research does not necessarily correspond with quality, the pattern of growing capability is clear.

This trend is producing further structural changes:

- Growing connections between multiple, globally dispersed innovation hubs.
- Growing capital availability (VC, SWF, banks) in alternative global centers.
- Repatriation to home countries of U.S.-trained entrepreneurs and technologists in response to government incentives and growing business opportunities.
- Research specializations in emerging economies that resemble those of industrialized economies, including in domains where the Bay Area has developed deep specialization—ICT, cleantech and life sciences.
- Entrepreneurs, financiers and corporations forming global networks to access local markets and qualified local labor pools. In the latter case, companies are not simply looking for cheaper labor, but also for the largest and deepest pools of qualified talent.
- Technology transfer, which was formerly in one direction from industrialized to developing economies, now includes "reverse innovation" and bi-directional transfer[28] from developing to industrialized markets, as seen in the following innovations.

  Portable Ultrasound Devices
  Using a solution originally developed in India, General Electric has developed a portable ultrasound device that is handheld and priced at only $8,000. Typically, ultrasound machines sell for more than $100,000.

  Tata Nano
  The Tata Nano is a small, inexpensive automobile developed and produced by Tata Motors of India. The $2,500 vehicles are fuel-efficient and will soon be launched in Europe.

[27] Han Zhang and Martin Kenney, "Building Global-Class Universities: An Assessment of Chinese Government Policies," research paper, (August 24, 2011).

[28] Jeffrey Immelt and Vijay Jovindarajan, "How GE is Disrupting Itself," *Harvard Business Review*, (October 2009).

Mobile Payment Systems
Developed nations have been searching for a way to handle mobile commerce and payments. Meanwhile, banking is being revolutionized in the developing world, with mobile payment systems bringing banking services to low-income individuals in cities and rural areas.

Pointing to polycentric and reverse innovation models of innovation around the globe, Navi Radjou calls for a new era of innovation strategy: "The best way for an MNC [multinational corporation] to shape (and lead) a market is by building up more local R&D capabilities and cultivating a vibrant local partner ecosystem so it can systematically design and market locally-relevant offerings."[29]

Leading MNCs are already implementing these strategies:

Cisco
"Cisco Globalization Center East" in Bangalore opened in 2007 as Cisco's second global headquarters, designed to engage and access the world's major emerging economies.[30]

Hewlett-Packard
HP Labs is headquartered in the Bay Area, where 40–50% of its global work is done, but also maintains an extensive laboratory network in the U.K. (Bristol), Israel (Techneon), India (Bangalore), Singapore, China (Beijing), and Russia (St. Petersburg), as well as smaller research relationships with entities in Brazil, Puerto Rico and Mexico.

IBM
The IBM Research–Almaden laboratory in San Jose is one of eight major labs IBM operates globally, and it is the key node in its global research network. Together the network employs approximately 3,000 persons at major labs and smaller facilities in Dublin and Sao Paulo. Products are developed through collaboration across multiple centers, based on specific areas of expertise.[31]

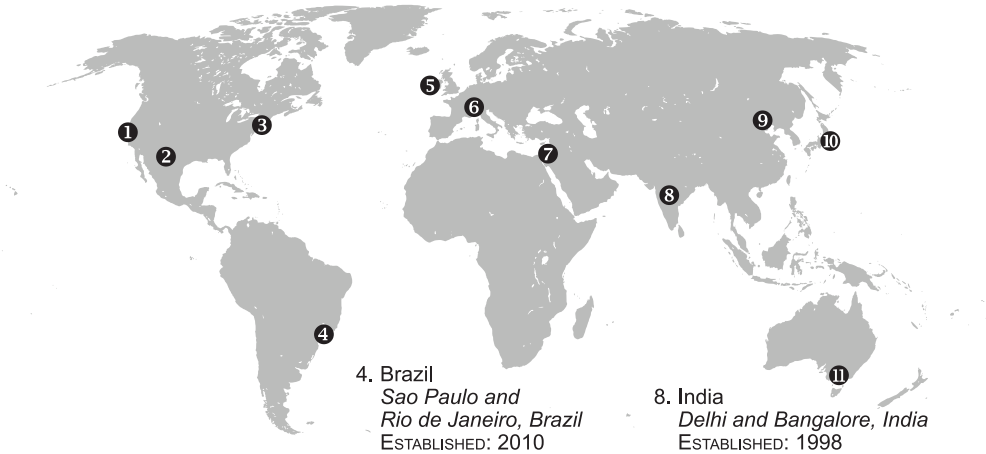
[29] Navi Radjou, "Polycentric Innovation: The New Global Innovation Agenda for MNCs", *Harvard Business Review*, (November 2009).

[30] Cisco's Technology News Site, "Cisco Selects India as Site for the Cisco Globalization Center," http://newsroom.cisco.com/dlls/global/asiapac/news/2006/pr_12-06c.html (accessed June 1, 2012).

[31] IBM, "IBM Research–Almaden," http://www.almaden.ibm.com/ (accessed June 1, 2012).

IBM's network of scientists works on a range of applied and exploratory research projects in research centers across the globe.

IBM Research Global Labs



1. Almaden
   San Jose, CA, USA
   ESTABLISHED: 1965
2. Austin
   Austin, TX, USA
   ESTABLISHED: 1995
3. Watson
   NY and MA, USA
   ESTABLISHED: 1961
4. Brazil
   Sao Paulo and Rio de Janeiro, Brazil
   ESTABLISHED: 2010
5. Ireland
   Dublin, Ireland
   ESTABLISHED: 2010
6. Zurich
   Rüeschlikon, Switzerland
   ESTABLISHED: 1965
7. Haifa
   Haifa, Israel
   ESTABLISHED: 1973
8. India
   Delhi and Bangalore, India
   ESTABLISHED: 1998
9. China
   Beijing, China
   ESTABLISHED: 1995
10. Tokyo
    Yamato, Japan
    ESTABLISHED: 1982
11. Australia
    Melbourne, Australia
    ESTABLISHED: 2010

SOURCE: IBM Research, www.research.ibm.com

Why Are These Changes Important for the Bay Area and the U.S.?

The paradigm of polycentric innovation is the new reality of the global innovation economy in which the Bay Area needs to position itself. From a regional and national economic standpoint, this is important because it spurs two critical, related questions for policy makers and executives:

- Where does economic value get created and extracted?
- Where do the associated jobs and social stability get generated?

Products and services that are conceived and designed in the Bay Area and produced in Asia create revenue that largely stays in the Bay Area, but many of the jobs that result do not. Moreover, as more products are designed or customized for local markets at overseas facilities and are also manufactured there (at facilities where the latest technology is available and new concepts can be tested), applied research activity and jobs have increasingly flowed overseas. In the six years ending in 2009, 85% of the growth in R&D workers

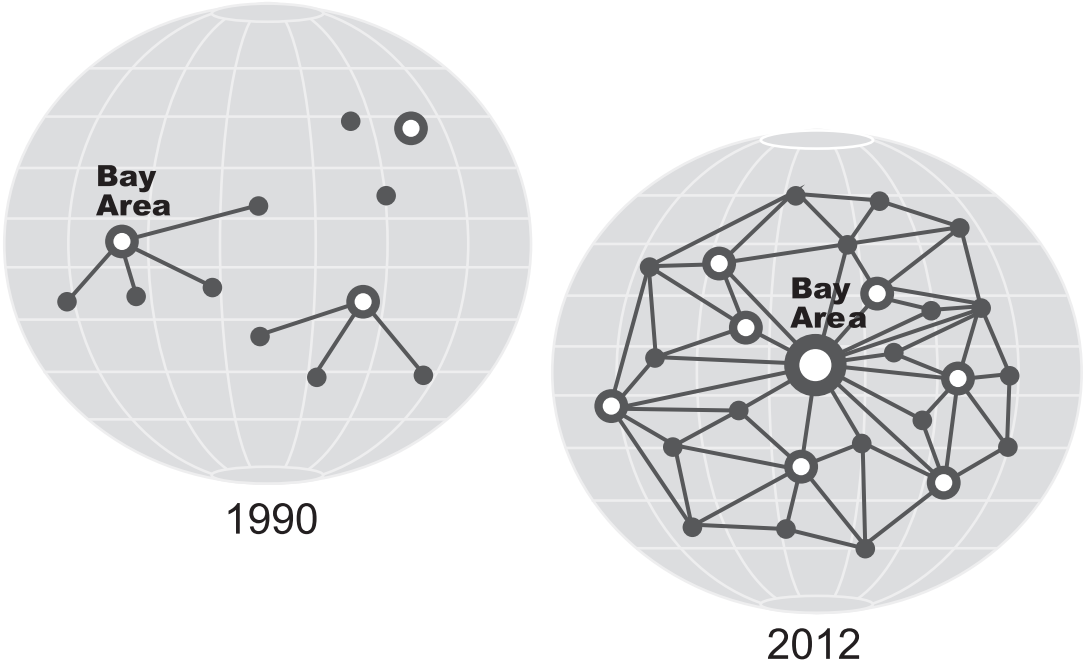
employed by U.S.-based multinational companies was overseas, with the overseas portion of their total R&D employment growing from 16% to 27%.[32]

Where Does This Leave the Bay Area Innovation System?

The Bay Area's ability to take advanced research, add sophisticated problem framing and design solutions, and assemble multidisciplinary teams to incubate and scale the resulting solutions is still unique. It benefits from a culture of mobility and fluidity and the compounding effect of having executed on this model (see illustration on page 15) for the past five decades across cycles of boom and bust. The Bay Area also has the distinction that—more than any other economic region—it functions not just as a research center, but as a global marketplace of ideas, talent and capital. In this sense, the Bay Area is uniquely positioned as a "Super Hub" that links other innovation hubs through the exchange of best practices, joint research and venture investment.

The illustration below provides a high-level conceptualization of the evolving global innovation landscape in which the Bay Area "Super Hub" operates.

Diffusion of Global Innovation Centers



[32] James Haggerty, "U.S. Loses High-Tech Jobs as R&D Shifts Toward Asia", *Wall Street Journal*, January 18, 2012.

Singularity University

Singularity University is an institution built on global ties, providing a marketplace for ideas that support both problem solving and innovative technological applications. It is also an example of the kind of organization that flourishes in the Bay Area. Founded in 2007 by Peter Diamandis, founder and chairman of the X Prize, and Ray Kurzweil, author of *The Singularity is Near*, Singularity is a non-degree-granting institution located at NASA Research Park, in the heart of Silicon Valley. Its stated goal is to use interdisciplinary methods to "positively impact humanity by assembling, educating, and supporting future leaders across the globe who can harness the power of exponential technologies to improve the lives of a billion people within a decade." This idea derives from Kurzweil's concept of "singularity" as a moment of dramatic technological change and from the need to foresee its implications and opportunities.

Singularity University's programs focus on accelerating technologies and their intersections to address grand global challenges, drawing on core faculty from Stanford, MIT, Carnegie Mellon and other universities, as well as on experts and executives from business. Offerings are built around a highly selective 10-week summer Graduate Studies Program, and multiple 4–7 day Executive Programs for entrepreneurs, executives and innovators that focuses on six technology areas: artificial intelligence and robotics, nanotechnology, biotechnology and bioinformatics, medicine and neuroscience, networks and computing systems, and energy and environmental systems. Students selected for the Summer 2012 Graduate Studies Program come from 34 countries, with 70 countries represented in the University's combined portfolio of programs.

To continue to capitalize on its strengths, respond to the polycentric innovation challenge, and build its ties to other global hubs, the Bay Area needs perspective on both its strengths and its weaknesses, and it needs strategies to support and leverage assets and address its challenges.

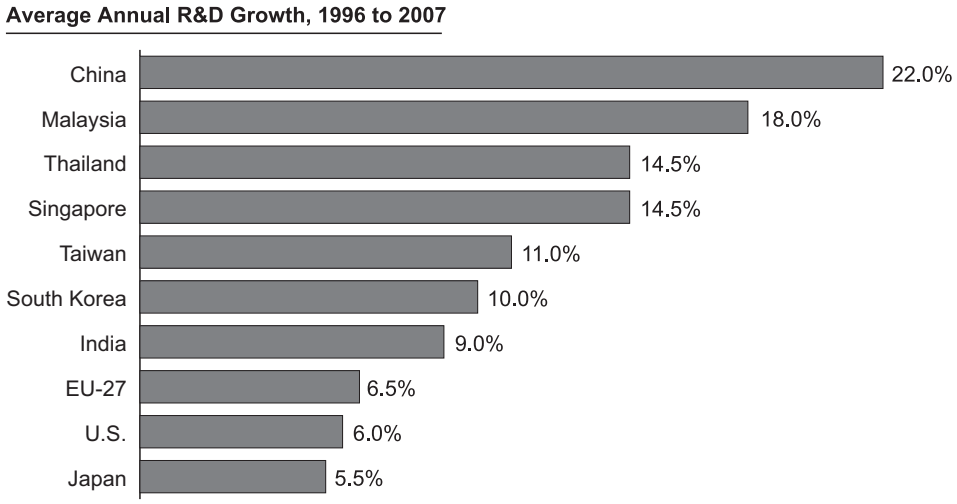
Support for R&D and Education

Federal support for basic research has led to countless innovations—many with applications that were unforeseen—that have generated new industries and game-changing technologies. The involvement of the Defense Advanced Research Projects Agency (DARPA, or ARPA, as it was originally called) in giving birth to the Internet is often cited. Another lesser-known example is in the field of robotic surgery. Original investment from DARPA, as well as the National Science Foundation (NSF) and other federal funding sources, supported the development of Intuitive Surgical's da Vinci Surgical System, a breakthrough in robotic-assisted minimally invasive surgery (MIS). Founded by Dr. Fred Moll, a graduate of UC Berkeley and Stanford, Intuitive Surgical,

Inc. is headquartered in Santa Clara and is now the global technology leader in robotic-assisted MIS. The company employs hundreds of PhDs and manufactures its products in California. Yet another example is GPS, a technology initially produced for the U.S. Air Force and Department of Defense, that today produces at least $67 billion in annual economic benefit in the U.S.: $20 billion in agriculture (for precision farming), $9 billion in engineering and construction, $10 billion in transportation and $28 billion in other commercial applications.[33]

Constrained federal and state budgets have impacted spending on R&D and education, however, even as emerging markets such as China are increasing their funding. Yet, these areas are the foundational assets for a healthy innovation-driven economy. This challenge is particularly evident in the United States, where historic support for these innovation assets is under pressure. While the United States still maintains a dominant position in research spending in terms of total dollars spent, the absolute numbers can be deceptive. In recent years, federally-sponsored R&D, after accounting for inflation, has stagnated, while other nations have been investing heavily.

Led by China's double-digit annual R&D spending increases, Asia's share of world R&D investment is expected to surpass the Americas in 2012.



SOURCE: Battelle, R&D Magazine

China, in particular, is expanding its R&D activity. In 1995, the country's R&D expenditures were about 0.6% of GDP, but by 2011 they had almost tripled to an estimated 1.6% of GDP. If this growth continues, Battelle forecasts that in 2023 China will surpass the U.S. in total dollars spent per year. Other

[33] Ron Hatch and John Deere Intelligent Systems Group, "Precision Agriculture and Space Weather," AGU Science Policy Conference, May 2012.

Asian countries shouldn't be ignored. Between 1996 and 2007, while the U.S. average annual R&D growth rate was 6%, India, South Korea, Taiwan, Singapore, Thailand, Malaysia and China all grew their R&D expenditures at significantly higher rates, with China's average annual R&D growth registering at 22%. Since then, the U.S. R&D growth rate has declined and is forecasted to be 2.1% for 2012.[34]

In this context, it is noteworthy that a new generation of overseas R&D institutions is receiving significant government funding for strategic initiatives, and many are seeking to attract top talent. For instance, the King Abdullah City of Science and Technology (KACST) now has 2,500 employees, and its sister institution, the King Abdullah University of Science and Technology (KAUST), has in excess of $10 billion at its disposal. Singapore, China and India are also investing in new R&D centers to attract and repatriate the best and brightest scientists.

As federal government involvement has stagnated, industry is picking up a larger share of U.S. R&D. While that is positive for business and the companies that invest, a declining share of federally-supported basic research relative to industry-led applied research points to a second issue: the erosion of support for the kind of deep research that enables breakthrough technological innovation. Lately, the dollar amount of corporate R&D investment has declined, further pointing to the risk in overreliance on private investment to compensate for lower federal commitments.

In California, state budget cuts are impacting a critical component in the Bay Area innovation system: education. A 2009 report by the Public Policy Institute estimated that California will be short almost one million college-educated workers by 2025.[35] In a state where 90% of higher education is being provided by public institutions, meeting this demand will fall to the UC, CSU and CCC systems, even as budget cuts are impairing their ability to deliver. A subsequent 2012 study by PPIC finds that enrollment rates at UC and CSU have fallen by one-fifth over the past five years, from 22% of all high school graduates to below 18%. Many of those not going to UC or CSU are opting for community colleges but face limitations there as well. Should these enrollment trends continue, while the need for skilled workers grows, California and its economy risk a serious talent shortfall.[36]

[34] Battelle, *2012 Global R&D Funding Forecast* (Columbus: Battelle, 2012).

[35] Public Policy Institute of California, *Closing the Gap: Meeting California's Need for College Graduates* (San Francisco: PPIC, 2009).

[36] Public Policy Institute of California, *Defunding Higher Education* (San Francisco: PPIC, 2012).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6.
System Elements in Transition

Several key elements of the Bay Area's innovation system are particularly impacted by these pressures. They are adjusting to changing circumstances, but whether they can do this quickly, and at the same time sustain their historic contribution to the system, is an open question.

National Labs—Evolving Economic Models

In recent years, the national laboratories complex has been undergoing its most significant reorientation since it evolved from the Manhattan Project in the years after World War II. From being more or less exclusively focused on nuclear capabilities and securing the stockpile of nuclear arms for the U.S. Departments of Energy and Defense, slowly but steadily, the labs have started to diversify their operating mission and customer sets.

Unmatched in their scientific and technological expertise and still vital to U.S. national security concerns, the labs first diversified their national security portfolio by instituting the Work for Others (WFO) program, putting their science and technology expertise to use for other U.S. agencies. In a second transition, the labs have begun opening to the private sector, offering their expertise on a contract basis for large-scale research projects and programs. Most recently, they have expanded their industry focus to include technology licensing, small business spin-offs, cross-institutional incubation partnerships and the commercialization of lab-originated technologies.

Together, LLNL and Sandia have begun work on their Livermore Valley Open Campus, destined to be an unclassified research and development space. Meanwhile, Lawrence Berkeley National Lab has announced plans for a second campus, also focused on a more open innovation model.

"Given the complexity of today's problems, to achieve the best solution there is no substitute for 'team science' across a diverse set of labs regionally, nationally and globally."
— *Edward J. Turano, PhD*
Head, Strategic Planning
Lawrence Berkeley National Laboratory

At this writing, funding for the labs, while not growing, is also not declining. Given the pressures on the federal budget, this is a relatively favorable situation. It is also an uncertain and unstable situation, as cuts could come at any time. To provide the right base for these types of discussions with political decision makers, an appraisal of the labs' return-on-investment and future funding should include an analysis not only of their national security value, but also of their contributions to the larger regional and national innovation ecosystems.

From a Bay Area standpoint, making substantial funding cuts to any of the regional labs' campuses is a risky undertaking. To be sure, change at the labs will continue to be required as the nation's national security requirements and the labs' customer sets evolve. Work for Others (WFO) will likely continue to expand, and the labs will increasingly turn to regional, national and international private sector clients that have a need for contract research. Already, some of the labs, such as LBNL, are hiring specialized staff to scale up these contract research programs. This reorientation towards a new set of customers will require a transitional period that allows the labs to build the right capabilities and relationships. Should cuts or consolidation happen abruptly or on a large scale, disruptions to new or existing operations and partnerships could result, including

- increased transaction costs for new private sector partners who engage with the labs;
- limits to the range of experimentation by the labs with new services and business models;
- loss in diversity of skill sets (basic science, applied research, engineering) for collaboration on big and complex problems.

> *"…fundamental research is ultimately the source of most innovation, albeit often with long lags. Indeed, some economists have argued that, because of the potentially high social return to basic research, expanded government support for R&D could, over time, significantly boost economic growth.…The Internet revolution of the 1990s was based on scientific investments made in the 1970s and 1980s. And today's widespread commercialization of biotechnology was based, in part, on key research findings developed in the 1950s. Thus, governments that choose to provide support for R&D are likely to get better results if that support is stable, avoiding a pattern of feast or famine."* [37]
>
> — *Ben Bernanke*
> *Chairman, Board of Governors of the Federal Reserve System*

Federal policymakers should therefore sustain support for both basic research and the labs' core mission, as well as the continued diversification of federal laboratory programs through outreach to the private sector. One element of this process, known as ACT (Agreement for Commercializing Technology), is particularly important to the quality of future private sector interaction. Currently it can take as long as two years for a private partner to negotiate an intellectual property agreement with federal labs. To move at a pace that aligns more closely with business and economic change, this needs to shorten. Announced by the Department of Energy in January 2012, ACT is a pilot program, initially involving LLNL and several other labs, that aims to facilitate IP agreements by streamlining the approval process.

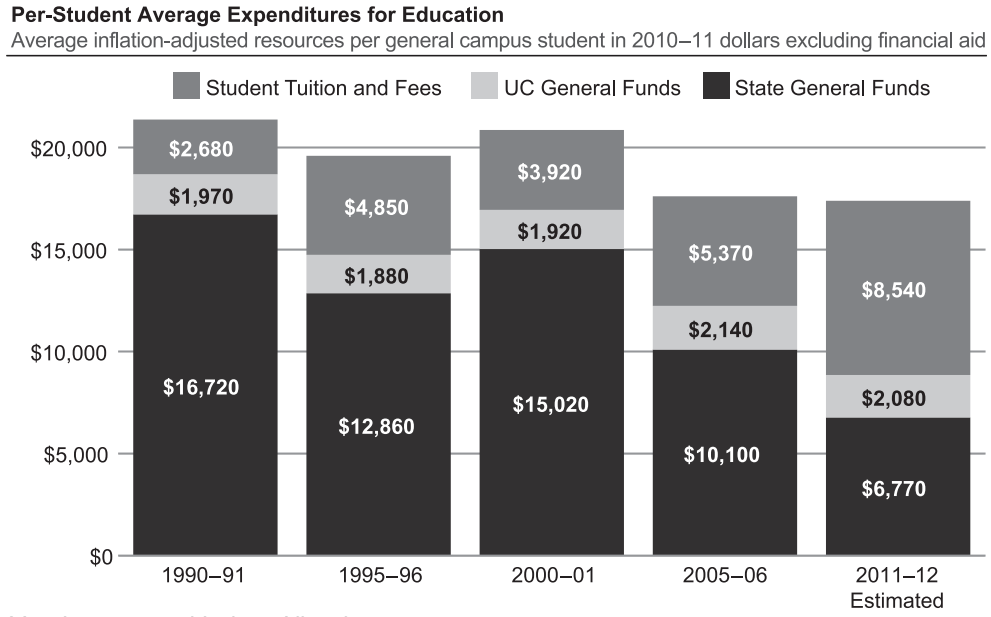
[37] Ben S. Bernanke, "Promoting Research and Development: the Government's Role" (remarks presented at the conference "New Building Blocks for Jobs and Economic Growth," Georgetown University, May 16, 2011).

The UC , CSU, and CCC Systems: Ensuring the Resilience of Critical Economic Assets

While the national labs are not yet experiencing funding cuts, California's public higher education system has seen a dramatic fall in support. This is a critical issue for the state and for the Bay Area innovation system.

Support for the UC system is declining, with the state contributing 60% less for student education than in 1990, (measured using inflation-adjusted dollars). This has led to a quest for new economies and revenues, such as fewer classes, higher tuition, reduced library staff and fewer acquisitions, and increasing the number of out-of-state students (who pay full tuition). Total state support for the University of California system is now at the same level as it was in 1998 when the system had 75,000 fewer students than it does today. Those 75,000 students are the equivalent of having an additional UC Berkeley campus plus an additional UCLA campus in the system. Students must now pay for a total of 49% of their educational costs, up from 13% in 1990, pushing tuition close to $12,000 a semester.[38] After years of reductions, each new wave of cutbacks cuts closer to the bone of the university's core mission.

Since 1990–91, the state's share of expenditures for educating a UC student has declined by 60%.

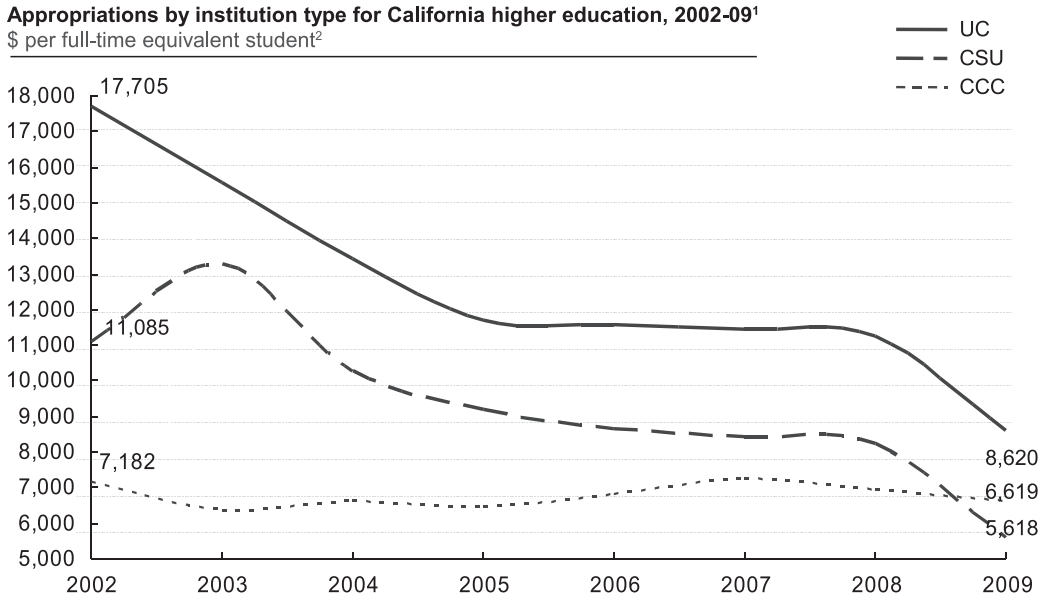


SOURCE: University of California Office of the President

[38] University of California, "The Facts: UC Budget Basics," http://budget.universityofcalifornia.edu/files/2011/12/Budget_fact_11.29.11.pdf (accessed June 1, 2012).

CSU faces a similar situation. State support for the CSU system has been reduced by $750 million, or 27.5%, in the 2011–12 fiscal year. Unlike UC, CSU's budget is fully dependent on General Fund appropriations and tuition, giving it less flexibility to respond to declining state support. In 2007–08, the state provided approximately $3 billion, a figure that has since then fallen to roughly $2 billion—a drop of 38%. The effects of this $968 million reduction are exacerbated by mandatory cost increases—such as employee health care benefits—that are not covered by the state. Since 2007–08, tuition fee increases have generated an estimated $593 million in new revenue. This, however, leaves a deficit of $510 million in resources for instruction, student services and operations.

State support per full time equivalent student has been cut by approximately 50% for both the UC and CSU systems since 2002.



1 Figures in 2002 dollars
2 State funding is allocated on the basis of full time equivalent students
SOURCE: Shulock, N. et al, "Dollars and Sense",*Institute for Higher Education Leadership & Policy.* Sacramento, 2011. p. 14.

While the CSU system, like UC, is looking to wring out costs through administrative and other efficiencies, the impacts of further cuts are likely to include reduced library acquisitions, deferred maintenance, the elimination of sports and athletic programs, and significant workforce reductions. In 2011, CSU adopted a 2.4% reduction in its enrollment target, from 339,873 California resident full time equivalent students, to 331,716. Enrollment in the spring of 2012 was actually 341,250, 2.9% above the budgeted target, due largely to admissions approved the previous year. This over-target enrollment is being served in 2011–12 with one-time resources, suggesting

that the impact of actual programmed reductions has yet to be felt. In March 2012, CSU campuses were instructed to restrict enrollment, in part by closing spring semester transfers.

If the system were to absorb a further $200 million in budget cuts in 2012–13, it would at that point be operating at the same level of funding as 1996, but with 90,000 additional students. Should that occur, further tradeoffs will be required between enrollment, increased fees, workforce size (85% of the CSU budget is for personnel), administrative structures and program offerings. Also on the table are more radical structural changes which could fundamentally alter the nature of CSU as an institution of public education.[39]

While UC has responded by raising tuition, it is also taking other steps. Its "Working Smarter" initiative is aimed at increasing system-wide administrative efficiency by centralizing programs such as travel, risk management and payroll. At a different level, the University is developing a pilot program called "U-Learning" to provide web-based for-credit instruction.

Beyond their impacts on education, budget cuts may impact university partnerships and technology transfer. In UCSF's case, where industry-sponsored research is substantial, state support has historically covered administrative costs. As that support is reduced, there is a reasonable possibility that those administrative costs will be taken directly out of program budgets, thereby reducing the effectiveness of research programs. This can already be seen in a reduction of support for intramural research within the UC system. At UC Santa Cruz and elsewhere, industry cooperation and technology transfer programs may be given lower priority, as resources are concentrated on the university's core mission of education. For example, staff that once interfaced with the VC community has been eliminated. Reflecting on the depth of budget cuts, one UC technology transfer leader observed, "UC was originally a state university, then became a state-aided university, and is now a university located in the state."

Funding for the California Community College system is also under pressure. Per student funding is lower than in 1995–1996, after inflation. In 2009–2010, California community colleges turned away 140,000 students due to lack of funding and served 200,000 students for which they received no funding. Declining budgets are also reflected in course reductions, facilities closures, increased class size, furloughs, position eliminations, administrative consolidation and reduced student services, as well as moves to increase efficiency such as online instruction, IT efficiencies and increased industry partnerships.

Foothill De Anza Community College District, for example, has seen a 20% cut in income since 2008–2009: state funding has dropped by $36 million, from $179 million to $143 million. As a result, 454 instructional and support

[39] Minutes of Meeting of Public Finance, Trustees of the California State University, March 20, 2012.

staff have been cut (a 15% reduction in staff serving students), the number of students served dropped by 11%, and student enrollment was reduced by 3,600. Further complicating this picture is the fact that cuts at UC and CSU campuses are inhibiting transfers and pushing more students back toward community colleges.

A continuation of this trend across the California public higher education system carries significant risks for the region's innovation system:

- Diminution of workforce talent in the region and the state.
- Reduced capacity to attract world-class faculty in what is an increasingly competitive environment.
- Impaired capacity to attract federal and private research funds.
- Diminished educational effectiveness across the three-tiered California system.
- An erosion of economic leadership and the corresponding ability to generate technologies and businesses that support jobs, growth and taxes.

Immigration: A Critical Supply Line of Research and Entrepreneurial Talent

Immigration has been vital to the region's skilled and diversified labor pool. A 2007 study, *America's New Immigrant Entrepreneurs*, found that 25% of all start-ups had at least one immigrant founder. For Silicon Valley that number was even higher: 52% of Silicon Valley companies reported that their key founders were immigrants.[40] In the past 5 years, more than 75,000 immigrants with college or higher degrees have moved from other countries to the Bay Area.[41] Examples of well-known Bay Area companies with foreign-born founders are legion, from Sun Microsystems (Vinod Khosla) to Brocade (Kumar Malavalli) and Google (Sergey Brin). Most recently Instagram, a social media company acquired in 2012 by Facebook for $1 billion, was cofounded by Mike Krieger, a Brazilian citizen who came to California in 2004 to study at Stanford and after graduating stayed to work in Silicon Valley on an H-1B visa.

"For us as a corporation, it doesn't matter whether we hire a particular PhD here in the Bay Area or in India in terms of process or cost. But it does matter to us in terms of the accumulated talent here in the Bay Area that enriches the exchanges that are so critical to innovation."

— John Sontag
Director, Strategic Innovation and Research Services
HP Labs

[40] Gary Gereffi, Ben Rissing, AnnaLee Saxenian and Vivek Wadhwa, "America's New Immigrant Entrepreneurs," Duke University and University of California Berkeley (2007).

[41] Bay Area Council Economic Institute and McKinsey & Company analysis using Current Population Survey 2010 data.

This flow of top global talent to the region is also under threat. Federal immigration policy has become increasingly complex and politicized, as H-1B and green card bottlenecks have deterred foreign students and educated immigrants from coming to the United States and have discouraged those already here from staying.[42] Commentator Vivek Wadhwa cites the figure of over one million immigrants waiting each year for one of 120,000 permanent-resident visas (in the employment categories EB-1, EB-2, EB-3) specially issued annually for skilled workers. This is occurring at a time when other economies (particularly other English-speaking countries such as the U.K., Canada, Australia and New Zealand), recognizing their value as competitive assets, are actively courting foreign students and educated immigrants. At the same time, economic growth in China and India is attracting more Bay Area residents from those countries who came as students to return home.

For the present, the Bay Area and the U.S. as a whole retain their appeal for many of the best students and scientists from overseas, due principally to the quality of our universities and research institutions, entrepreneurial culture, and transparency (in contrast, for example, to China where restriction on the free flow of information is a self-imposed barrier), and top talent continues to come here. But we should not assume that, in the absence of more thoughtful federal policies, this will be true indefinitely.

"In this new age of globalization we cannot afford to close our doors to foreign talent if we want to continue to attract the best and the brightest."
— Robert Carling, PhD
Director, Transportation Energy Center
Sandia National Laboratories

The value of these highly educated immigrants to the economy, particularly in technology fields, can be immense: a top scientist can generate $30–100 million in direct and indirect value over the course of his or her career. This dwarfs the value of licensing or IP considerations that tend to dominate public discourse on innovation.[43] One measure of the economic contribution of immigrants is patents. A 2012 study by the Partnership for a New American Economy found that more than three out of every four patents at the top 10 patent-producing U.S. universities (76%) have at least one foreign-born

[42] H-1B temporary visas are issued for workers with highly specialized knowledge and at least a bachelor's degree in their field. Science, technology and engineering occupations account for nearly two-thirds of applications, with computer-related occupations representing half of all requests. The Bay Area generates the largest number of applications after New York and the most concentrated pool of applications relative to the size of its economy. (See "Geography of H-1B Workers: Demand for High-Skilled Foreign Labor in U.S. Metropolitan Areas," by Neil G. Ruiz, Jill H. Wilson and Shyamali Choudhury, forthcoming in July 2012 from the Brookings Institution Metropolitan Policy Program.) With the exception of two years following the dot-com bust, H-1B visa demand in the last decade has consistently outstripped supply.

Green cards, which are typically issued to individuals already residing in the U.S., entitle their holders to permanent residency in the United States and are available to foreign nationals with extraordinary ability in the sciences, arts, education and business (among other qualifications).

[43] John Sontag, HP Labs, interview, April 2012.

inventor. More than half of all patents are awarded to the group of foreign-born inventors most likely to face visa hurdles (students, post-doctoral fellows, or staff researchers) and foreign-born inventors play a particularly large role in cutting-edge fields like semiconductor device manufacturing (83%), information technology (84%), pulse or digital communications (83%), pharmaceutical drugs or drug compounds (79%) and optics (77%).[44]

From the standpoint of innovation-driven economic development and its contribution to the state and national economies, the concerns are clear. Decreased inflow and increased outflow of top-level talent will diminish the diversity and depth of the region's talent pool, which observers in both industry and the research community cite as the Bay Area's biggest asset. This, in turn, puts at risk both technology development and business formation (entrepreneurial activity) that supports growth and competitiveness. To stem this development and meet the needs of the U.S., California and the Bay Area for world-class talent, immigration policy issues relating to highly educated knowledge workers and their residence in the U.S. (green cards and H-1B and other visas) need to be separated from the policy debate on undocumented workers and immigration generally and addressed on their merits. Green cards merit particular attention, as many of their recipients (or candidates) have come to the U.S., primarily at the graduate or postdoctoral level, through university programs and screening processes that allocate places based on academic excellence and achievement. These people are also best positioned to contribute to the economy for the long-term.

Access to Capital

Access to capital is a perennial issue for start-ups and young companies. Angels and venture capitalists help entrepreneurs cross the "valley of death" between development of the initial product and commercial viability. As the large-scale IPOs and frothy returns of the dot-com boom have diminished, most venture firms have shifted in the direction of larger investments in later-stage companies. This is especially true for the cleantech and life sciences sectors, which often have large capital requirements or long lead times to profitability. Some observers also note a shift of investor interest from long-term plays that require significant technology R&D to shorter-term investments with quicker payouts in fields such as social media.

In biotech, a diminished pipeline of successful drug products, driven by a cautious FDA, high drug development cost and lack of IPOs has reduced the appetite of limited partners (pension funds, etc.) to fund venture capital. In 2006, 34 biotech VC funds raised $4.6 billion, while in 2010, 15 funds raised $1.1 billion.[45] In 2007, aggregate biotech venture funding for start-ups

[44] Partnership for a New American Economy, *Patent Pending: How Immigrants Are Reinventing the American Economy* (June 2012).

[45] Stacy Lawrence, "Venture's Street," ("Fewer VCs Reload" sidebar), *BioCentury on BioBusiness*, October 10, 2011.

was $5 billion; in 2010 the investment figure dipped to below $3 billion. In 2011 investments went up by 21% to $7.5billion[46] but the number of deals went down and deal size increased. This continues a trend in life sciences of VCs focusing on larger, later-stage deals and of fewer new companies receiving funds. In addition to placing increased pressure on young, entrepreneur-led companies, this trend is influencing corporate strategies. In a 2012 survey, 44% of participating biotech CEOs said they would look to licensing agreements and corporate partnerships as a source of financing in the next 12 months—double the number giving that answer in 2011.[47]

The scarcity of funding for Series A, pre-clinical research particularly affects the movement of technology from university research to the market. In response, biotech entrepreneurs are starting leaner and are operating with a lower capital burn rate. They also use more virtual organizational structures with fewer employees and more work (such as chemistry and clinical trials) outsourced to contract research organizations (CROs), often in other countries. At the level of basic research, the region's biotech community remains as large and as innovative as ever, and it is adapting to changing financial circumstances through increased use of incubators and corporate venture funding. Because of biotech's capital requirements and long lead time before products come to market, early-stage biotech companies are clearly more vulnerable to funding constraints than their counterparts in IT and social media.

"Being in the Bay Area enables us to bring outside innovation into Siemens, offering the corporation's business units valuable external insights and sorting hype from valuable trends, often challenging mindsets in the process. At the same time, we also understand commercialization and product development processes. This tight coupling makes for better success rates for entrepreneurs and corporations."

— *Chenyang Xu, PhD*
General Manager
Siemens Technology-To-Business Center

In the cleantech sector, stimulus funding from programs launched during the last recession is ending, making the path to profitability more difficult for many companies. With budget and other issues in Washington calling future incentives into question, and with low-cost competition from countries such as China increasing, solar companies face particular challenges. And cleantech companies that need to manufacture have capital requirements that in most cases exceed the scale available through venture capital. As a result, venture capital firms are increasingly partnering with private equity to see their investments through to later stages.

Venture capital will undoubtedly remain the key financial enabler for start-ups and young, entrepreneurial companies. But to start their companies and

[46] PricewaterhouseCoopers, *MoneyTree*, February 2012.

[47] BayBio, *2012 California Bio-Medical Industry Report* (San Francisco: BayBio, 2012).

bridge to profitability, entrepreneurs will look increasingly to diversified funding sources and partner relationships. These will likely include larger corporations and possibly sovereign wealth funds. For example, Siemens Technology-To-Business (TTB) Center in Berkeley has developed a successful and cost-efficient model for screening, incubating and connecting young ventures to the larger corporation. TTB uses its cultural translation capabilities to ensure that its external start-ups integrate effectively with Siemens' corporate business units, increasing the success rate of ventures that can scale through the corporation's global network.

The Manufacturing–R&D Link

Even as the U.S. and the Bay Area in particular have maintained the lead in basic research, applied research has increasingly flowed to other parts of the world, reflecting not only government commitments to research but also the pull of growing consumer markets and of large pools of educated talent. Manufacturing began shifting overseas several decades ago, initially in search of lower costs, but increasingly compelled by the same forces driving applied research. Lately, the two have moved in tandem, as localized research has shifted to be closer to both manufacturing and markets.

For U.S. multinationals, much of the value of the products that are manufactured overseas is captured by headquarters, due to the value of their intellectual property and the relatively low value contributed by the manufacturing process itself. There is reason to be concerned, however, that a loss of manufacturing knowledge and capability in the United States could eventually accelerate the outward flow of research. One driver is the ability of countries such as China to scale production more quickly. For example, solar IP (intellectual property) generated in the Bay Area is being sold to China due to a lack of production experience and scaling capacity here. With the shift of manufacturing overseas, the U.S. has already lost its edge in lithium-ion battery technology. Policies to enable the growth of advanced manufacturing in the U.S. therefore need to be considered in relation to their impact on the near- and long-term flows of intellectual property.

Innovation in production processes, as distinct from new inventions, is closely connected to the economy and job creation. As other global innovation centers focus on this kind of innovation—and link it with sophisticated manufacturing—the U.S. risks forfeiting many of the high-quality jobs created through its scientific prowess.[48]

[48] The case for a stronger U.S. focus on process and incremental production innovation and its connection to jobs is made convincingly by Peter Cowhey and Dan Breznitz in a February 2012 white paper produced for the CONNECT Innovation Institute, "Innovation, Production and Sustainable Job Creation: Reviving U.S. Prosperity—America's Two Systems of Innovation: Recommendations for Policy Changes to Support Innovation, Production and Job Creation."

7.
The Bay Area's Innovation System: Where Are We Going?

Looking back over the past few decades, much of the applied research and engineering that was once performed exclusively in the Bay Area has been replicated elsewhere—particularly in lower cost environments that at the same time offer growing markets. Innovation centers have proliferated around the world, and lean ("jugaad") and reverse innovation are teaching industrialized economies that scarcity can be an asset and not a limitation.

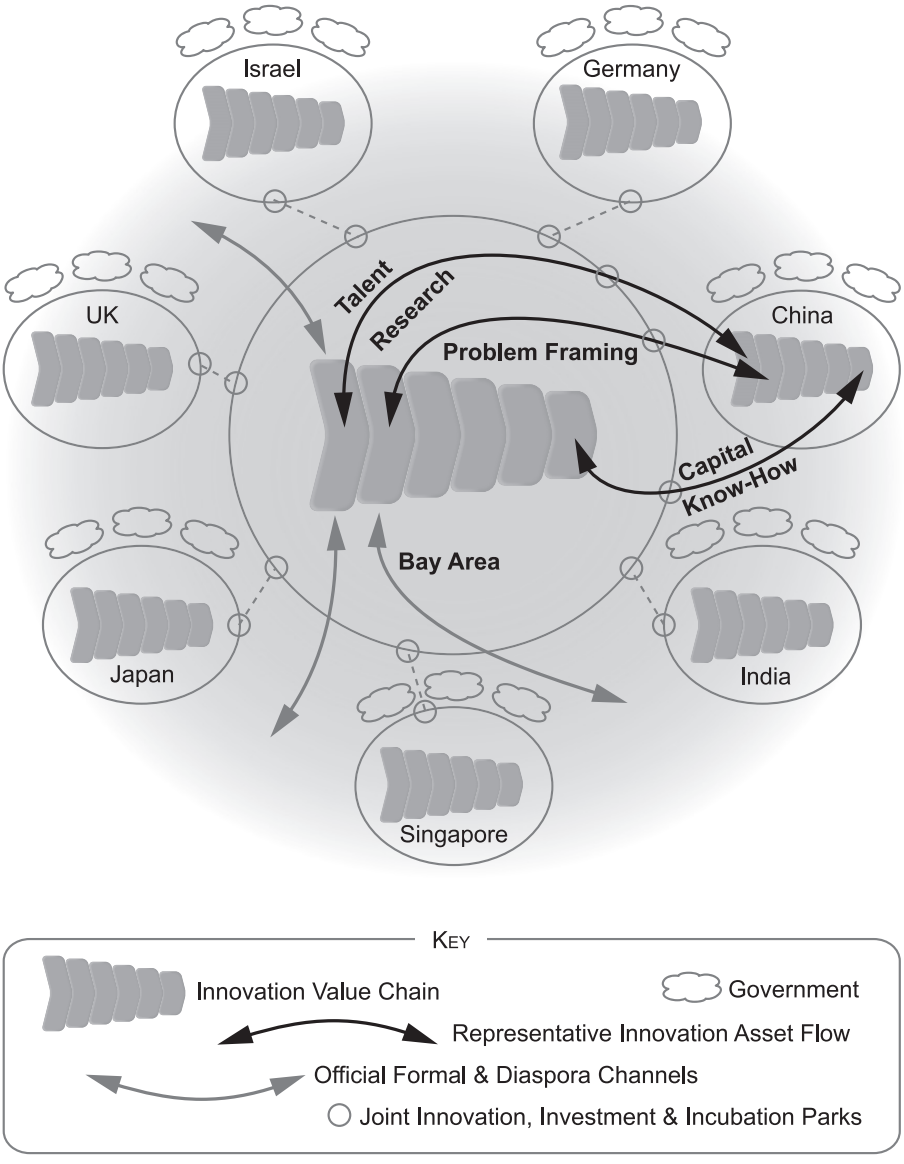
The new polycentric innovation economy benefits from the Bay Area's role as the premier global center of innovation, and the region in turn benefits from a growing array of relationships that draw on diverse capabilities and talent pools around the world. The region retains its preeminence due to the strength and diversity of its core and non-core assets and the fluid, integrated nature of its innovation value chain. Its deep research capacity in conjunction with an entrepreneurial and highly educated talent base should continue to produce game-changing innovation. The comparative openness and integrated nature of this innovation system and the compounding effects of its experience and skill in translating research into commercial opportunity are not easily replicated.

Also, the depth and diversity of the Bay Area's technology domains enable deep cross-disciplinary exchange, which helps technologies combine and recombine in innovative ways. This is particularly important as the region tackles convergence spaces between domains, such as digitized energy and infrastructure, computational and synthetic biology, healthcare and educational ICT, and 3D printing and advanced manufacturing. These are the new growth frontiers.

No less important—but more difficult to quantify—is the region's role as a marketplace of ideas. A culture of taking and rewarding risks and of accepting failure (which encourages innovators to try new things) as well as the permeability of business and institutional barriers that allows people and information to flow with relative freedom are nowhere as deeply engrained as here. A cosmopolitan climate of cultural tolerance and extensive global connections helps draw creative individuals and the companies they lead and staff to participate in the region's innovation economy and gain a competitive edge.

This unique combination of attributes should, for the foreseeable future, position the Bay Area as a core partner and point of connection with other innovation centers around the world and an integrator of world scale.

The Bay Area Innovation Value Chain in the Polycentric Global Innovation Economy



In light of the pressures discussed above, however, it would be short-sighted to assume that this preeminent position will continue in perpetuity. Other regions will continue to learn and build capacity, as they should. In response, the Bay Area must sustain and build its competitive assets, remain open, and assure the continued integrity of its innovation value chain.

Recommendations

To sustain the Bay Area's innovation system and its continued ability to generate societal benefits and wealth, the following local, state and federal measures should be considered.

Bay Area Innovation System Overall

- A deeper conversation between VCs, entrepreneurs, and university, lab, corporate and government executives to identify and alleviate transaction costs of collaborating.

Education

- Strengthened financial support for public higher education at all levels.
- Expanded collaborations of business with education, to support STEM (science, technology, engineering and mathematics) and skills development in priority technology fields.
- Policy support within the community college system for the development of regional collaboratives such as the Bay Area Community College Consortium, to scale course offerings, leverage multiple campuses, and facilitate interaction with industry around future skills needs.
- Policy support from state government for educational innovation to reduce restrictions that unnecessarily inhibit the ability of colleges and universities to collaborate with industry to create value and generate new sources of revenue.

Research and Development

- Sustained or increased support for basic research, through the U.S. Department of Energy, the National Institutes of Health, and the National Academies of Science, with an appropriate balance between physical and life sciences.
- Attention to federal policies in areas such as export control (Export Administration Regulation) and arms control (International Traffic in Arms Regulation) that may unnecessarily inhibit research.
- Improved processes for intellectual property management, to lower barriers to technology transfer and joint research between universities, national laboratories and industry.
- Continued development of hybrid research models, to better enable structured research collaboration between universities and industry.
- Development, through structured umbrella agreements, of research consortia of national labs with investors and university and industry partners to conduct team science.
- Strategies to enable process innovation and advanced manufacturing as sources of jobs and key rungs on the innovation ladder.

Entrepreneurship and Immigration

- Cultivation of a business and regulatory environment that continues to support new business formation and growth.
- Programs that facilitate access to capital and nurture entrepreneurial talent at educational and nonprofit institutions.
- Immigration policy reform, to ensure access to the best global talent through increased access to H-1B and other visas for highly skilled workers and to green cards for students graduating from U.S. universities with advanced STEM degrees.

Infrastructure

- A focus on wireless/broadband infrastructure as a competitive asset and platform for business development and technology deployment.

Conclusion

The Bay Area supports a unique value chain of research institutions (universities and independent and corporate laboratories), private companies, investment finance, specialized supporting services, and cultural attributes that have enabled it to become an innovation super-hub. The game-changing technologies and new business paradigms created here have benefitted not just the regional economy, but the state, national and global economies as well.

It is the breadth, depth and dynamism of the region's innovation ecosystem that permits it to innovate, collaborate and compete on a global scale. The key to this process is not just the system's components, but the fluidity with which they interact. The regional innovation system has been open to participation by creative individuals and partners from throughout the world, with few barriers to entry or movement within the system. This openness has enabled innovation on a large scale, as well as an unparalleled record of commercialization with all its benefits.

The Bay Area's innovation value chain is only as strong as its links, however. Because they do not exist in isolation, but connect to form an integrated and interdependent system, the erosion of one or more of these links can threaten the viability of the entire system.

Even with growing innovation capacity abroad, the Bay Area continues to support the world's most robust innovation system. Because of its distinctive attributes, the region's innovation system is uniquely positioned as a global-scale partner and integrator. Its continuing success is an important interest not only to the region, but to California, the nation and its global partners.

Appendix

Venture Capital and Private Equity Firms in the Bay Area (Partial List)

Aberdare Ventures
Abingworth Management, Inc.
ABS Capital Partners
Acacia Venture Partners
Accel Partners
Accell-KKR LLC
Access Venture Partners
Acer Technology Ventures America
Acorn Ventures, LLC
Adams Capital Management, Inc.
Advanced Technology Ventures
Adobe Ventures
Agilent Ventures
Alacrity Ventures
Alafi Capital
Alameda Venture Capital
Allegis Capital
Alloy Ventures
Alta Partners
Altos Ventures
AltoTech Ventures, LLC
AmBex Venture Group
American Venture Capital
Aragon Ventures, Inc.
Ark Venture Partners
Apax Partners
ArrowPath Venture Partners
Artisan Ventures
Asia Pacific Ventures
AsiaTech Ventures Limited
Asset Management Company
Astellas Venture Capital LLC
ATA Ventures
ATEL Ventures, Inc.
Atherton Venture Partners, LLC
Atrium Capital Corporation
August Capital
Azure Capital Partners
Battery Ventures
Bay City Capital
Bay Partners
Bedrock Capital Partners
Benchmark Capital
Berkeley International Capital Corp.
Bessemer Venture Partners
BioVeda Capital
Blacksmith Capital
Blue Chip Venture Company
Blueprint Ventures
BlueRun Ventures
Blumberg Capital
Boston Scientific
BrainStorm Ventures
Burrill & Company
BV Capital
Cambrian Ventures, Inc.
CampVentures, LLC
Canaan Partners
Cardinal Venture Capital
Cargill Ventures
Carlyle Group
Catamount Ventures
Celerity Partners
Charles River Ventures
Charter Life Sciences
Chess Ventures
ChinaVest
Clearstone Venture Partners
CM Capital Corporation
CMEA Capital
Compass Technology Partners
Correlation Ventures
Crescendo Ventures
Crosslink Capital
Crosspoint Venture Partners
Chevron Technology Ventures
Crystal Ventures
DCM
De Novo Ventures
Delphi Ventures
Diamondhead Ventures
Dominion Ventures
Dot Edu Ventures
DragonVenture
Draper Fisher Jurvetson
Draper Richards, LP
Duff Ackerman & Goodrich LLC
EarlyBird
East Gate Group
El Dorado Ventures
Elevation Partners
Emergence Capital Partners
Entrepia Ventures, Inc.
Evolvence Life Sciences Fund
Expansion Capital Partners
Explorador Capital Management LLC
Felicis Ventures
Fisher Lynch Capital
5AM Ventures
Flywheel Ventures
Focus Ventures
Formative Ventures
Foundation Capital
Founders Fund Management
Fox Paine & Company, LLC
Francisco Partners
Frazier Healthcare Ventures
Friedman Fleischer & Lowe
FTVentures
Fundamental Capital, LLC
Fuse Capital
Gabriel Venture Partners
Garage Technology Ventures
Garnett & Helfrich Capital
General Atlantic Partners
Generation Partners
Genstar Capital, LLC
Gerken Capital Associates
Global Catalyst Partners
Globespan Capital Partners
Glynn Capital Management
Golden Gate Capital
GGV Capital
Granite Ventures, LLC
Greylock Partners
GSMR Ventures
Hambrecht & Quist Capital Management, LLC
Hattery Labs
Headland Ventures
Hellman & Friedman LLC
Hercules Technology Growth Capital
Highland Capital Partners
HIG Ventures
Horizon Ventures
Hotung Capital Management, Inc.
Hummer Winblad Venture Partners
ICCP Venture Partners, Inc.
IDG Ventures Pacific
Incubic Management LLC
Industrial Growth Partners
Industry Ventures
InnoCal Venture Capital
In-Q-Tel
Institutional Venture Partners
Integral Capital Partners
Intel Capital
International Venture Partners
InterWest Partners
INVESCO Private Capital

J.P. Morgan Partners
Jafco Ventures
Kaiser Permanente
Kennet Venture Partners LLC
Kenson Ventures, LLC
Key Principal Partners, LLC
Kleiner Perkins Caufield & Byers
KLM Capital Group
KT Venture Group
KTB Ventures
Khosla Ventures
Labrador Ventures
Lake Street Capital, LLC
Latterel Venture Partners
Lauder Partners, LLC
Leapfrog Ventures
Learn Capital
Legacy Venture
Levensohn Venture Partners
Lexington Partners
Lighthouse Capital Partners
Lightspeed Venture Partners
Lumira Capital
Manitou Ventures
Matrix Partners
Mateva Capital, LLC
Mayfield Fund
McKenna Ventures
MedVenture Associates
Menlo Ventures
Meritech Capital Partners
Mithril Capital Management
Mobius Venture Capital
Mohr Davidow Ventures
Montreux Equity Partners
Morgenthaler
MPM Capital
MyQube
Najdorf Capital
Needham Capital Partners
NeoCarta Ventures, Inc.
New Enterprise Associates
New Millennium Partners
Nexit Ventures
NIF Ventures
Norwest Venture Partners
Noventi Ventures
Novus Ventures
Nth Power
Oak Investment Partners
ONSET Ventures LLC
Opportunity Capital Partners
Osprey Ventures LP
Outlook Ventures
Pacific Partners
Pacifica Fund
PacRim Venture Partners
Palo Alto Venture Partners
Paloma Ventures
Parker Price Venture Capital, Inc.
Partech International
Parthenon Capital
Paul Capital
Peninsula Equity Partners
Pinnacle Ventures
Pitango Venture Capital
Pond Venture Partners
Presidio Venture Partners, LLC
Propel Partners
Prospect Venture Partners
Psilos Group
Quicksilver Ventures
Red Rock Ventures
Redpoint Ventures
Redwood Venture Partners
Rembrandt Venture Partners
Rho Capital Partners
Ridgewood Capital
Rocket Ventures
Rosewood Capital
Rustic Canyon Partners
RWI Group
SAIF Partners
Saints Capital
SAP Ventures
Salix Ventures
Sanderling Ventures, Ltd.
SB Life Science Equity Management, LLC
SBV Venture Partners
Scale Venture Partners
Shelby Venture Partners
Sequoia Capital
Sevin Rosen Funds
Shasta Ventures
Shoreline Venture Management
Siemens Venture Capital
Sienna Ventures
Sierra Ventures
Sigma Partners
Skyblaze Ventures
Skyline Ventures
Sofinnova Ventures
Southeast Interactive Tech Funds
SpaceVest
Split Rock Partners
Spring Ridge Ventures
Sprout Group
Storm Ventures
Summit Partners
Sutter Hill Ventures
SV Life Sciences
Swander Pace Capital
Sycamore Ventures
TA Associates
Tailwind Capital
Tallwood Venture Capital
Taraval Associates, LLC
TAT Capital Partners Ltd.
Technology Crossover Ventures
Technology Investments
Technology Partners
Telesoft Partners
Tenex Greenhouse Ventures
Thoma Cressey Bravo
Thomas, McNerney & Partners
Thompson Clive Venture Capital
Three Arch Partners
3i Corporation
TI Ventures, LP
TL Ventures
Ticonderoga Capital
Trinity Ventures
TriplePoint Capital
U.S. Venture Partners
Vanguard Ventures
VantagePoint Capital Partners
VCFA Group
Vector Capital
venBio
VenGlobal Capital
Venrock
Venture Frogs
Versant Ventures
Vertex Management Inc.
Vertical Group
Vision Capital
Vivo Ventures
Voyager Capital
VSP Capital
Walden International
Walden Venture Capital
Warburg Pincus
Weber Capital Management, LLC
Thomas Weisel Venture Partners
Western Technology Investment
WI Harper Group
Weston Presidio
Woodside Fund
Worldview Technology Partners
X/Seed Capital

SOURCE: Springmeyer Law; Bay Area Council Economic Institute

The Bay Area Science and Innovation Consortium (BASIC) is an organization of the Bay Area's leading research and innovation companies and institutions, which together constitute the world's greatest body of technology innovation capacity. Its participants include public and private universities, national laboratories, and leading private sector companies. BASIC's mission is to advance the science, technology and innovation leadership of the Bay Area, California and the nation. By bringing together the university technologists, laboratory directors, CEOs and CTOs who lead the region's world renowned research organizations, this unique multi-sector collaboration provides a platform through which the Bay Area's science and innovation community identifies and addresses issues and opportunities impacting the region's innovation leadership and its role as the world's leading marketplace for ideas.

By addressing regional, state and national issues, and working to expand the Bay Area's research enterprise, BASIC is a unique regional voice that makes a difference. In cooperation with the Bay Area Council Economic Institute, the independent 501(c)(3) research arm of the Bay Area Council, BASIC has published forward-looking reports, convened innovation leaders, addressed federal policy issues affecting the research community and helped bring new research institutions and funding to the region. Through BASIC, members communicate with government and community leaders, addressing issues from federal support for basic research, to higher education and the importance of a globally competitive science and technology workforce. The weight of its members and the experience of its leaders make BASIC an influential voice on the importance of science and innovation to the regional, state and national economies.

The Bay Area Council Economic Institute is a partnership of business with labor, government, higher education and philanthropy, that works to support the economic vitality and competitiveness of the Bay Area and California. The Association of Bay Area Governments is a founder and key institutional partner. The Economic Institute also supports and manages the Bay Area Science and Innovation Consortium (BASIC), a partnership of Northern California's leading scientific research universities and federal and private research laboratories. Through its economic and policy research and its many partnerships, the Economic Institute addresses key issues impacting the competitiveness, economic development and quality of life of the region and the state, including infrastructure, globalization, science and innovation, energy, and governance. A public-private Board of Trustees oversees the development of its products and initiatives.

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