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California Innovation Corridor

Global Benchmark Case Studies

CALIFORNIA SPACE AUTHORITY

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LABOR & WORKFORCE DEVELOPMENT AGENCY

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California Innovation Corridor Project Overview

Implementation of the Advanced Technical Assistance provided to the California Innovation Corridor (CIC) under a Department of Labor WIRED grant

Overview:

This project aims to develop a market-driven economic development model that will guide policymaking on innovation, entrepreneurship, technology transfer and commercialization. We have outlined the following steps for the project:

1. **A Working Definition of Innovation:** Develop consensus with CIC on a definition of innovation that is flexible, creative, and can be acted upon.
2. **Regional Benchmark Selection:** NES, in conjunction with CIC, will select 6 regions on which to conduct detailed case studies.
3. **Regional Case Study Composition:** Each regional case study will consider a number of factors, including assets, programs, policies and obstacles.
4. **CIC Innovation Gap Analysis:** What programs, assets or best practices can the California Innovation Corridor adopt from other regions?
5. **Regional Innovation Model:** Provide data and strategic guidance for a working model of a robust innovation ecosystem based upon case study work.

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Case Study Approach

Approach to the Regional Case Studies

Purpose: The purpose of the regional benchmarking process is to identify innovation best practices from around the world and apply those that are relevant to the California Innovation Corridor

Regions for comparison: Boston, India, Finland, Singapore, Israel, Korea, and Brazil

Selected questions used to guide analysis of regions by NES:

- What are the region's industry clusters that are relevant to California and are performing well?
- How have the region's primary industry clusters evolved in the past 10-20 years?
- What policies, conditions and assets have contributed to the successful growth of the cluster?
- What obstacles were overcome?
- What role have universities played in cluster development?
- What metrics does the region use to track its "innovation economy"?
- Did the region follow a pre-existing model or did they develop their own? What organizations/ intermediaries oversaw the model's implementation?
- What can California learn from the case study and possibly adopt?

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Boston

Overview of Greater Boston Innovation Infrastructure

Basic Statistics

- ***Population:*** *4.4 million (Greater Boston)*
- ***Per capita Income:*** *$32,101*
- ***Unemployment Rate:*** *4.4% (Dec. 2006)*
- ***Primary Business Locations:*** *Downtown Boston, Cambridge, Waltham (Rte 128), Hopkinton (I-495)*

Key Assets

Innovation Base: Top research universities such as Boston Univ, Tufts, MIT and Harvard; strong federal R&D base (MA ranked first in both federal funding per capita and SBIR awards per capita nationwide); strength in patenting (ranked second to CA in patent generation per capita (2005 data))

Industry Base: Strong industry clusters include Computer and Communications Hardware, Life Sciences, Software and Communications Services, Postsecondary Education, and Defense. Firms include: EMC, Avid, Akamai, Bose, Genzyme, Meditech, Raytheon, Bain & Co.

Workforce: Highly educated workforce (36.6% of adults have Bachelor's degree or higher); one of the largest concentration of scientists and engineers in labor force nationwide.

Global Recognition: One of the largest innovation clusters globally (MA responsible for estimated one-third of world's biotechnology); history of academic excellence and commercial spin-offs (MIT is a leader in technology transfer).

Successes in Innovation

Boston has traditionally been one of the primary locations for research & development in the United States, primarily due to its concentration of **higher education research universities**. The Radiation Laboratory at MIT developed radar systems and other important technologies during World War II. Many of these discoveries were commercialized by Boston-area firms in post-WWII period. The **Defense Cluster** is presently represented by firms such as Raytheon. More recently, firms such as Genzyme Corporation, have helped establish a leading Life Sciences Cluster in the Greater Boston area.

Challenges to Continued Innovation

Ongoing innovation challenges include:

- Retaining and attracting its highly educated workforce; out-migration of younger workers; inability to retain college graduates and scientists
- Boston is not home to many corporate HQs and Boston area start-ups, once acquired, are often located elsewhere.
- Increased competition from other states and countries for funding of academic research & development; often this competition is for a flat or declining pool of funding, as with the NIH.
- While Boston is the home of several venture capital firms, increasingly these firms have been directing their investments away from seed and early stage to later stages in the investment process. This directs capital away from start-ups that have long been the source of future innovation and employment for Massachusetts.

Example Economic Development Strategies / Programs

LifeTech Boston: An initiative administered by the Boston Redevelopment Authority to attract, retain, support and strengthen Boston companies engaged in biotechnology, pharmaceuticals, medical devices and related industries. The initiative seeks to assist companies by establishing new sources of financial capital, pre-permitting certain sites for office and research locations, developing workforce training programs, and helping to meet the transportation needs of prospective companies.

The Johns Adams Innovation Institute: Affiliated with the Massachusetts Technology Collaborative, this organization provides seed financing between $50,000 and $500,000 for start-ups that are "transitioning from research & development and the marketplace." The Johns Adams Innovation Institute also publishes an annual Index of the Massachusetts Innovation Economy. An edition has been published from 1996-2006, providing valuable information on innovation metrics and benchmarking Massachusetts against other "Leading Technology States", such as California, New York, Pennsylvania.

Innovation Corridor

Sources: U.S. Census Bureau; Boston Indicators Project; LifeTech Boston; the John Adams Innovation Institute

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The Relevance of Greater Boston Innovation Infrastructure to the California Innovation Corridor

California and Massachusetts both rank at the top of many innovation metrics such as Federal R&D funding, patenting and SBIR grants. Due to their different, size, location, and demographics, however, each state faces divergent challenges. (It is relevant to study Massachusetts as a whole to consider state policies and in addition, Greater Boston encompasses a significant portion of the state.)

- In studying innovation best practices, CIC has selected 5 global regions along with one domestic region, Boston. This choice underlines the fact that US states are increasingly looking to develop global markets for their products, in addition to globally competing for talent and capital. Massachusetts and California are in direct competition for knowledge workers and trade partners.
- Top export partners (MA): Canada, Germany, Japan, UK, China, France, Taiwan, South Korea, Mexico
- Top export partners (CA): Mexico, Japan, Canada, China, South Korea, Taiwan, UK, Hong Kong, Germany, Singapore
- Given its location on the West Coast, California's trading partners are primarily Asian nations. Does California have the proper distribution of trading partners? For both California and Massachusetts, India does not rank in the top 10. What can be done to develop India as a trading partner?
- What efforts are being made to facilitate trade abroad by smaller firms, both start-ups and smaller traditional firms?
- What is the composition of goods exported abroad by California? While there is more diversity than Massachusetts in the share of export total of top 10 commodities (24.4% vs. 36.6%), this is far below other states such as PA or NC.

CA and MA cluster employment concentrations as compared to national 2005 data. The following industries were identified as most relevant for both California and Massachusetts

Cluster	MA	CA
Business Services	0.98	1.06
Computer & Comm. Hardware	1.62	1.83
Defense Manufac. & Instrm.	1.48	1.39
Diversified Industrial Support	1.12	0.33
Financial Services	1.40	0.87
Healthcare Technology	1.20	1.30
Postsecondary Education	2.84	0.91
Scientific, Technical & Management Services	1.50	1.20
Software & Comm. Services	1.35	1.12
Textiles	1.08	1.66

California Innovation Corridor

Comparative Data taken from the Massachusetts Innovation Index, 2006

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India

Overview of India's Innovation Infrastructure

Basic Statistics

- ***Population:*** *1.1 billion*
- ***Per Capita GDP:*** *$3,800 (PPP)*
- ***Unemployment Rate:*** *7.8%*
- ***Primary Business Locations****: Mumbai, Chennai, Bangalore, Delhi*

Key Assets

Innovation Base: The. Indian Institutes of Technology - a network of independent universities primarily focused on engineering education and located in Bombay, Madras, Guwahati, Delhi, Roorkee, Kangpur, and Kharagpur. The IITs were established between 1951 and 2001 with the express goal of contributing to the social development of India through technology. Extensive government programs were also directed by the Ministry of Science & Technology.

Industry Base: Industry clusters displaying economic growth include IT, Biotechnology and Telecommunications. However, agriculture is still estimated to employ 60% of the workforce. Other traditional industries include manufacturing, textiles, chemicals, food processing.

Workforce: Large population of young, increasingly skilled workers, many of whom are fluent in English. There is a strong push to increase the skill sets, especially in engineering and science, held by the workforce.

Global Recognition: Over the last decade India has developed a reputation as a location for research and development and offshore services for western firms, particularly in software development.

Successes in Innovation

Since the liberalization of the economy in the early 1990s, India has developed its innovation capacity, particularly in IT (software, consulting services), Life Sciences (CROs, pharmaceuticals, agricultural biotechnology, enzymes). Support and coordination for the biotechnology sector has been provided by the **Pharmaceutical Research and Development Support Fund (PRDSF)** and the **Drug Development Promotion Board (DDPB)**. Efforts are being made to bring innovation to other sectors of the economy, including manufacturing and financial services.

Challenges to Continued Innovation

India has worked to overcome several obstacles to the development of a robust economy driven by technology since the early 1990s, including:

- **Lack of risk capital.** Currently being addressed through the development of a domestic venture capital network and links to the United States capital markets, often through expatriate network
- **Intellectual Property.** Only in 2005 did India ratify the WTO agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), which imposed standard IP protections. Previously India's industries developed outside of these standards. While somewhat difficult to secure, IP standards offer a good incentive for the development of new products and services.

Example Economic Development Strategies / Programs

The Science and Engineering Research Council (SERC) is the state body that promotes research & development in India and is housed within the Ministry of Science and Technology. It is composed of leading academic and industrial researchers, engineers and scientists. The SERC has developed several programs since its inception in 1974 that have been directed to increase the innovation capacity of the country. These include:

- **The Fund for Improvement of S&T Infrastructure in Higher Educational Institutions (FIST)-** launched in 2000 to provide better research equipment, especially for emerging industries.
- **Intensification of Research in High-Priority Areas (IRHPA)** - a program that seeks to develop expertise in emerging/ high priority industries including: Neurobiology, Solid State Chemistry, Nano-materials, Plasma Physics, and Macromolecular Crystallography. Goals of IRHPA include creation of research units around outstanding scientists, developing national facilities in areas of government priority, developing multidisciplinary projects and training young scientists.

California Innovation Corridor

Sources: CIA World Factbook; Nature Biotechnology (Jan 05), Ministry of Science and Technology

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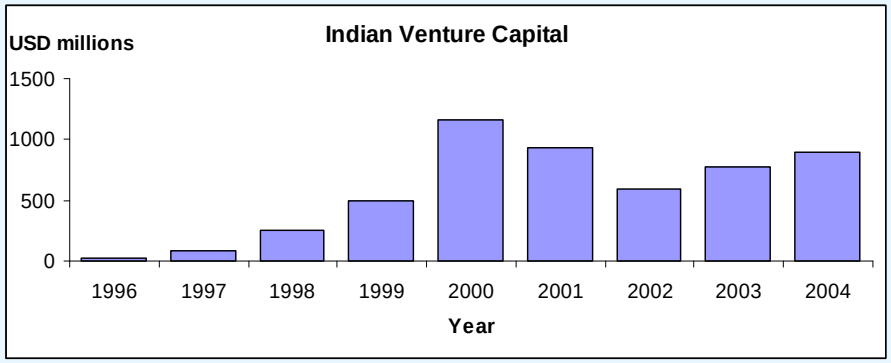
The Relevance of India's Innovation Infrastructure to the California Innovation Corridor



➢**Venture Capital**

India has developed a strong venture capital community that has helped finance much of the growth of the IT, Biotechnology and Telecommunications Sectors in recent years. The India Venture Capital Association (IVCA) is a structured organization comprised of registered funds, and it has a network across India and in the United States. It also provides guidance to the government on policy surrounding capital formation.

IVCA describes the development of the Venture Capital Industry in India as having progressed through several stages:

➢ Phase I - Formation of TDICI in the 80's and regional funds as GVFL & APIDC in the early 90s
➢ Phase II - Entry of Foreign Venture Capital funds between 1995-1999
➢ Phase III - (2000 onwards) Emergence of successful India-centric VC firms
➢ Phase IV – US VCs' increasing appetite to invest in India

While the total value of VC investment is hard to track, total VC in India has grown from less than $20 million in 1996 to over $1 billion in 2005. This growth has been in stark contrast to the decline and stagnation of VC in the US. Moreover, VC investment, both within India and from abroad has broadened from IT to include industries such as biotechnology, media, manufacturing and financial services.

Indian Business Clusters relevant to the California Innovation Corridor:

➢ **IT:** The IT industry in India primarily focuses on software and consulting services. This is often referred to as Information Technology Enabled Services- Business Process Outsourcing (ITES-BPO). This sector has experienced dramatic growth over the last decade. Market leaders such as Infosys Technologies and Satyam Computer Services each have revenue of over $1B USD and display quarterly revenue growth of over 25%. While Infosys and Satyam are both listed on US exchanges, their competitors Tata Consultancies and Wipro Technologies are not publicly traded. The Indian Embassy cites that over half of Fortune 500 companies outsource some of their software to India. Despite this, the IT services sector in India remains relatively young and small – comprised of just one million workers.

➢ The success of the Indian IT consulting sectors is attributed primarily to a few factors
  - ➢ A large pool of increasingly skilled English-speaking workers
  - ➢ Low business and labor costs
  - ➢ Extremely low cost of transnational telecom
  - ➢ A network of educational institutions that continue to develop a pipeline of engineers and computer scientists
  - ➢ Government policies supportive of the sector, including the launching of the Software Technology Park Scheme in 1991
  - ➢ Role played in Y2K readiness efforts

Sources: IVCA, Evalueserve

Finland

Overview of Finland's Innovation Infrastructure

Basic Statistics

- ***Population:*** *5.3 million*
- ***Per Capita GDP****: $33,700 (PPP)*
- ***Unemployment Rate:*** *7.0%*

Primary Business Locations: *Helsinki metro area, Tampere, Turku, Oulu*

Key Assets

Innovation Base: Twenty universities and twenty-nine polytechnics provide the basic research infrastructure in Finland. The University of Helsinki is the country's top research university. Universities are supported by 19 state research institutions and Technopolis, a series of five technology centers which provide operating facilities and business and development services to high tech companies in the area. Technopolis serves 930 companies and has one of the largest client bases in Europe. Finally, large private firms perform a significant amount of research, accounting for more than two-thirds of research expenditures in 2006.

Industry Base: Strong industry clusters in Electronics, Telecommunications, and IT. Firms include: Nokia, Elcoteq SE, UPM Kymmene, Kone, Sonera, TietoEnator, and Benofon.

Workforce: Finland has a highly educated workforce, with over 32% of the workforce (ages 25-64) having received a degree at a polytechnic or a university.

Global Recognition: Finland is a world leader in technology and design, with established expertise in telecommunications and information technology. It is especially recognized for innovation in mobile services and technologies, especially in the areas of digital and mobile phone technologies.

Successes in Innovation

Finland has had a strong history of innovation in telecommunications. As a participant in the Nordic Mobile Telephone research project, Finland acquired the appropriate knowledge base for its venture into consumer-oriented mobile communications. It went on to open the world's first Global System for Mobile Communications (GSM) network in 1992. Finland has produced world-class companies in the industry such as Nokia, a leading supplier of mobile cell phones and mobile, fixed, and IP networks. The country also hosts several niche leaders, with specialties such as mobile banking, which was launched by Meridea Bank in Singapore in 2005 and allows customers to access bank accounts and perform secure transactions from a wide variety of mobile networks.

Several metrics indicate the strength of Finland's innovation economy: Third in the world in R&D spending as a % GDP (3.6%) (2005); fourth in patents per capita (2005); top country in knowledge transfer between universities and companies (IMD World Competitiveness Yearbook 2006)

Investment in R&D

Finland's annual R&D investment was estimated to be around $7B in 2005 or 3.5% of its GDP. R&D investment has grown steadily over the past decade, and just over 70% of R&D funding is provided by industry.

Challenges to Continued Innovation

Finland's relatively isolated position and small domestic market makes it difficult to attract and retain firms in the region. As firms relocate to be closer to their markets, research facilities are often moved as well.

Example Economic Development Strategies / Programs

Tekes Technology Programs: Tekes, Finland's agency for technology and innovation, provides funding and expertise to around 2,200 R&D projects in targeted industries. On average, projects last about 5 years, with around 1,800 representatives from business and 500 from universities participating in these programs in a given year. Tekes provided an estimated $620 million in funding in 2006. Technology Programs have met with much success since they were started twenty years ago. Recent accomplishments include the a new gasoline production technology that has been brought to U.S. markets and a new monitoring and measuring system for ships pioneered by researchers in Helsinki.

Centers of Expertise Program: In this program, 22 Centers of Expertise gather, maintain, and share industry-specific expertise with private businesses in Finland. The program aims to create knowledge-intensive business and improve the competitiveness of existing companies. Taken together, these 22 Centers have 45 areas of expertise ranging from ICT to Chemistry and Plastics. The Centers are located throughout the country, and sites are chosen based on research, education, and business activities in the region.

Regional Economic and Development Centers (TE-Centers): Established in 1997, the fifteen TE-Centers located throughout the country provide financial support and advice to SMEs throughout their life cycle. These public service units are staffed with experts from Tekes and the Finnish Foundation for Innovation, and they assist throughout the process of establishing and growing a business.

California Innovation Corridor

Sources: OECD, CIA World Factbook; World Bank, Research.fi, Invest in Finland, Statistics Finland, EU Innovation Trend Chart report (2006)

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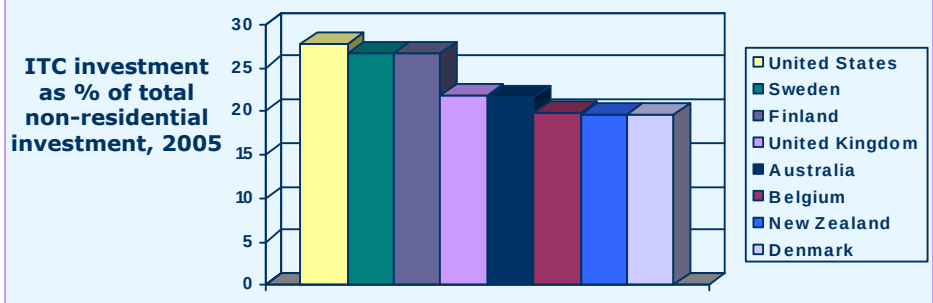
The Relevance of Finland's Innovation Infrastructure to the California Innovation Corridor



Source: OECD

➢Education as an Innovation Driver

Finland is consistently ranked among the top in the world for the strength and quality of its education system. It was ranked first by both the World Economic Forum (2006) and IMD (2004) in their respective competitiveness reports for its higher education and training based on overall enrollment figures and the quality of education programs.

Relative to its size, Finland has an extensive university system comprised of 20 universities and 29 polytechnic schools. Of the twenty universities, three are devoted exclusively to technology (located in Lappeenranta, Tampere, and Helsinki). Finland has promoted several programs to increase the quality of education and the quantity of graduates to support research needs, particularly in IT. Over half of the degrees in 2006 were awarded in engineering and life sciences, and nearly 3,000 of the 18,600 total degrees were awarded in engineering alone. The number of doctoral degrees has tripled in the last fifteen years, growing from 524 in 1991 to 1,409 in 2006. It is estimated that two-thirds of these degree recipients remain in research and development, continuing to support Finland's strong research base.

Finland also has an extensive adult education system. At the forefront is Dipoli, the Lifelong Learning Institute of Helsinki University of Technology, one of the premier continuing education institutes for engineering in Europe. It provides programs for management and leadership, security management, and tailored training programs, which are customized for individual companies and organizations.

Finnish Business Cluster relevant to the California Innovation Corridor:

➢Information and Communications Technology (ICT)

The ICT cluster is considered the core of the knowledge economy in Finland. The cluster has grown rapidly, increasing its share in total GDP from just 4% in 1990 to more than 10% in 2003. It represents around 4.7% of the value-add in manufacturing and 22.2% of the value-add in business services. This exceeds all other OECD countries including the U.S., where ICT accounts for 8.1% of the value-add in business services. Growth has been strong in this cluster, especially pertaining to ICT services in which growth exceeded 13% from 1995 to 2003.

Nokia: Since it was officially formed in 1987, Nokia has been a driving force in Finland's ICT cluster. It represents about 4% of the country's GDP and about 20% of total exports, which is about equal to exports in the entire paper and pulp industry. Nokia has had a series of successful innovations from the first car phone in 1982 (the Mobira 450) to the first handheld mobile phone for the Nordic Mobile Telephone network in 1987 (the Mobira Cityman). It also pioneered the first widely used mobile phone ring tones, which has since exploded on the consumer market. Nokia remains one of the largest mobile phone manufacturers and one of the leading providers of network services throughout the world. Its market capitalization in the U.S. was about $76 billion in 2006.

As the largest company in the country, Nokia subcontracts with an estimated 300 companies in Finland, fueling growth and innovation throughout the ICT cluster. Subcontractors include component manufacturers (Elqotec and Perlos), network operators (TeliaSonera and Elisa), and terminal manufacturers (Benefon, Suunto). Many of these companies have gone on to pioneer technologies of their own. Suunto has created watches with GPS positioning capabilities, and TeliaSonera's UMTS network, operational in the Helsinki area since 2002, is among the first UMTS networks in Europe.

Sources: Nokia; Invest in Finland; "ICT Cluster Review, 2005" (Tieke); Ministry of Education (KOTA database); OECD; Dipoli-TKK

Singapore

Overview of Singapore's Innovation Infrastructure

Basic Statistics

- ***Population**: 4.5 million*
- ***Per Capita GDP:** $31,400 (PPP)*
- ***Unemployment Rate:** 3.1%*

Key Assets

Innovation Base: Singapore has several universities including the National University of Singapore, Nanyang Technological University (NTU) and the Singapore Management University; it has also developed alliances with universities abroad, including the University of Munich through the German Institute of Science and Technology and the Singapore-MIT Alliance. Additionally, several multinational firms have R&D and production facilities in the country including a large concentration of US pharmaceutical producers located in Tuas Biomedical Park at the Western end of the island.

Industry Base: Strong industry clusters include Financial Services, Manufacturing (including petroleum refining), Life Sciences and Electronics. Firms include: DBS, OCBS, SembCorp, GES Intl., Star Hub, Singapore Telecom, Chartered Semiconductor and the Singapore Exchange Limited (SGX). In addition, there are several U.S. firms that have extensive operations in Singapore, including HP, Wyeth, GSK, and Merck. Primary government-controlled firms include: Temasek Holdings (US $80 billion in assets) and the Government of Singapore Investment Corp (manager of over US $100 billion in foreign exchange reserves).

Workforce: Singapore has developed a strong workforce that has powered the development of the nation as it moves up the value chain. The Singapore Workforce Development Agency has enacted many best practices around skills development, with programs targeted for many of Singapore's private industries.

Global Recognition: For several centuries Singapore has served as an distribution and trading center for the markets of Asia. Its status as a British colony resulted in a legal system that provides intellectual property protection. Over the last 20 years Singapore has developed itself as a producer of increasingly complex products and services.

Successes in Innovation

Since independence in 1965, Singapore has rapidly developed and now boasts one of the highest per capita income levels in the world. In exchange for limited political freedom, the government has facilitated the development of a robust market economy. In addition, the government controls a large portion of the economy through holding companies, including Temasek and the Government of Singapore Investment Corp.

Given its stable government, respect of property rights, and Common Law-based legal system, many multinational firms have used Singapore as a launch pad for business throughout Asia.

Investment in R&D

Over the past 20 years, Singapore has successfully moved up the value chain, which requires extensive investment in R&D. The government has been active in a variety of incentive programs and has successfully developed a skilled workforce that can staff research and production operations. Many firms have decided to locate an R&D operation in Singapore after a successful experience with production there. Recently the San Francisco-based biotechnology firm Genentech has announced plans to locate a $ 140 million facility for the production of Lucentis - a therapy for macular degeneration. Additionally, a facility for the firm Lonza exists and one for GlaxoSmithKline is being planned. Merck also has a manufacturing facility located at Tuas Biomedical Park.

Example Economic Development Strategies / Programs

The Ministry of Trade and Industry (MTI) will commit $681 million in 2006 to strengthen R&D capabilities through funding public sector research in the areas of science, engineering and biomedical sciences, as well as promoting private sector R&D investments through the **Research Incentive Scheme for Companies (RISC)** in the areas of biomedical science, environmental and water technologies, and interactive and digital media.
SPRING (Standards, Productivity and Innovation Board) will invest $689 million (including loans) in 2006 in entrepreneurial companies. There are several primary focus areas including: promoting a pro-business environment; championing industry development; enhancing enterprise capabilities and developing market access and opportunities.

The primary agency overseeing the development of research in Singapore is the Agency for Science, Technology and Research, **A*STAR**. It oversees and provides funding to multiple institutes through the Biomedical Research Council and the Science and Engineering Research Council. A*STAR has selected several priority clusters, including Pharmaceuticals, Medical Devices and Biotechnology and their related multidisciplinary efforts in areas such as Bioengineering and Bio-processing. A*STAR also directs the work of **Exploit Technologies**, its marketing and commercialization arm, which provides guidance for the protection of IP generated by A*STAR funded research and works to create successful spin-off firms.

Sources: CIA World Factbook; A*STAR, EBD, EPTL, IQPC

The Relevance of Singapore's Innovation Infrastructure to the California Innovation Corridor

Economic Development Strategies (Continued)

Singapore Science Park

While established by a government initiative, the Science Park is managed by Ascendas, a property management firm with facilities in China, India and the Philippines. In addition to offering business and lab space, the Science Park offers value-added services such as client promotion, market access and venture acceleration.

Ascendas has several commercial links with JTC, a property development firm and REIT traded on the Singapore Exchange. JTC has a series of "technopreneur centers" which provide broadband, shared space and business services. Under the **Technopreneur Incentive Scheme**, JTC offers reduced rates on incubation space for start-ups that meet certain requirements, including designation as an EDB SEED.

JTC is also a participant in the "HOT spots" (Hubs of Technopreneur) program, an initiative of the Singapore Economic Development Board (EDB), which brings together angel investors, VCs, start-ups, industry and academics, including the National University of Singapore and Nanyang Technological University.

Additionally, JTC has developed **Biopolis**, a S$500 million complex that comprises 185,000 sq ft. Biopolis houses facilities for both private sector R&D and research conducted by A*STAR, the government research authority, leading to the commercialization of basic research. Biopolis also demonstrates primary role of the Singapore government in the nations economic development efforts.

The Role of Government in Economic Development

Outside of any particular industry focus, studying the innovation policy of Singapore can highlight the central role played by government in economic development. Singapore's dominance by one political party has enabled the government to exercise great control over the nation's economic development policies, and the government uses its influence over business to advance these goals. Under its **Science & Technology Plan 2010**, the Ministry of Trade and Industry has agreed to spend S$7.5 billion ($5 billion USD) by 2010 on R&D efforts in key industry clusters. Of this, S$5.4 billion will go towards public sector R&D sponsored by A*STAR while the remaining S$2.1 billion will go towards supporting private sector R&D. By comparison, this spending level is similar to that provided by California's recent USD $3 billion stem cell initiative, despite Singapore being one-eighth the size of Singapore.

Singapore clusters relevant to the California Innovation Corridor:

Biomedical Research

The Biomedical Research Council (BMRC) is the arm of A*STAR that oversees public sector biomedical R&D. It coordinates the five research institutes that operate in this area: the Bioinformatics Institute, the Bioprocessing Technology Institute, the Genome Institute of Singapore and the Institute of Bioengineering and Nanotechnology and the Institute of Molecular and Cell Biology.

Electronics

Singapore has developed expertise as a semiconductor foundry and currently accounts for over 10% of the global market share of semiconductor wafers. It is home to over 14 fabrication plants and Chartered Semiconductor, a Singapore-based firm that is traded on NASDAQ and has a market capitalization of $2.4 billion USD.

Media and Broadcast

Singapore has developed a prominent role in Asia as a media center, which links strengths in broadcast, IT and telecommunications. A*STAR, through the Science and Engineering Council, is developing **Fusionopolis**, a science park that seeks to facilitate the development of Singapore's Media and Infocom sector.

Finance

Though government efforts at supporting innovation have been primarily directed towards science and engineering, Singapore also has opportunities for innovation in finance that will continue to support its role as a primary financial services hub in SE Asia. The market for finance that is in line with Islamic principles (**Islamic Finance**) is valued at over $300 billion and is expected to grow rapidly in coming years. Singapore, with its strong banking sector, links to the Gulf States and stable political climate could be a beneficiary of this trend.

California Innovation Corridor

Sources:; A*STAR, EBD, EPTL, IQPC

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Israel

Overview of Israel's Innovation Infrastructure

Basic Statistics

- ***Population**: 6.4 million*
- ***Per Capita GDP:** $26,800 (PPP)*
- ***Unemployment Rate:** 8.3%*
- ***Primary Business Locations:** Greater Tel Aviv, Jerusalem, Haifa, Beersheba*

Key Assets

Innovation Base: Top research universities include Technion-the Israel Institute of Technology, Hebrew University, Tel Aviv University and the Weitzman Institute of Science, which only provides graduate education. Extensive research & development is also performed by private firms and the military. Several American firms such as IBM and Google have R&D Centers in Israel. Intel, which has operated in Israel since 1974 has five facilities that include design and development, fabrication, and sales and marketing.

Industry Base: Strong industry clusters in Bioscience, Defense and IT. Firms include: Teva, Compugen, Israel Aerospace Industries, Elbit, Amdocs and Check Point Software.

Workforce: Israel has one of the most highly educated workforces in the world. Over 24% of the workforce has a first university degree, with an additional 12% holding an advanced degree. Additionally, 16% of the workforce has attained some post-high school education.

Global Recognition: Since independence in 1948 and increasingly over the last 20 years, Israel has developed global recognition as a leader in many areas of technology. Sectors that have displayed particular strength include Bioscience, Defense, Communications and IT.

Successes in Innovation

Innovation has been a hallmark of the State of Israel from its establishment in 1948. In the first several decades of Israel's existence, many of the innovations were agricultural technologies such as drip irrigation, which facilitated development of a robust and now-specialized agricultural sector. Since then, Israel has become an innovation leader in multiple sectors, many of which are also important to the economy of California.

Some well-known metrics speak to the strength of Israel's innovation economy: Second in the world in R&D spending as a percentage of GDP (3.6% in 2004); home to the third largest number of NASDAQ listed companies outside of the U.S. and Canada; and one of the largest recipients of venture capital both in absolute and per capita terms.

Investment in R&D

Israel's annual R&D investment is estimated to be close to $5B per year. While the government and military have traditionally played a primary role in research, 69% of Israel's R&D funding is now provided by industry, which is in line with OECD countries such as the United States and Switzerland.

Challenges to Continued Innovation

- **Political Risk:** The economy of Israel has successfully grown over the last 59 years despite regular conflicts with its neighbors. Regional trade has been limited and the United States alone counts for almost 40% of total foreign trade.

Example Economic Development Strategies / Programs

Youzma Program This was a government initiative that facilitated the successful development of a domestic venture capital industry in Israel. In 1993, $100 million was allocated to establish a fund of funds structure in conjunction with experienced foreign investors. Each fund was capitalized with $20-$25 million and divided 60%/40% between the Israeli government and foreign investors. Of 15 direct investments there were 9 successful exits - an enviable ratio. This program demonstrated the viability of VC in Israel and helped lead to the $10B currently under management.

Tnufa: This program assists start-up companies by evaluating the technology and market potential of a discovery or novel idea and assisting in the preparation of a business plan and patent proposal. It also assists in the construction of a prototypes as needed and the establishment of contact with industry. In addition to providing support of up to $50,000 for each project, efforts are made to attract additional investors.

Nofar: This program looks to close the gap between basic and applied research, something especially relevant to the biotechnology industry. Grants of up to $95,000 are given to biotechnology projects.

Heznek: This program links government investment in start-ups with external investors in exchange for non-voting rights shares. The government investment may not exceed NIS 5 million ($1.2 million) over two years and 50% of the start-ups working program. The investor has the option of buying-out the government's position at any time in the first seven years.

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Sources: CIA World Factbook; R&D Magazine, Battelle, OECD, World Bank, Israel Venture Capital Research Center, Israel Venture Association

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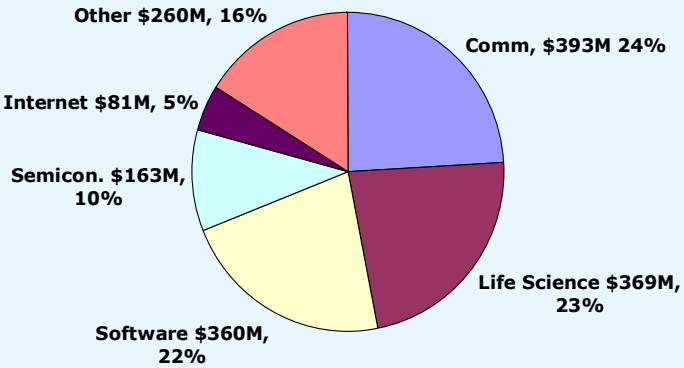
2006 Israel Venture Capital By Sector (in USD)



➢**Venture Capital & Entrepreneurship**

Israel boasts a very strong venture capital community, which, like India, has extensive links to the United States. Israeli venture funds have attracted nearly $10 billion in investment over the last 10 years. While investment peaked at $2.5 billion in 2000, there was nearly $500 million raised by Israeli VC firms in 2006. These numbers also do not account for the total investment in Israeli companies by U.S. and European venture capital firms. More than half of the $1.6 billion invested in Israeli "high-tech firms" (as defined by IVCRC) was provided by foreign investors.

Israel also looks to have a strong pipeline of start-ups as $138 million of funding was provided to Seed Stage companies. This accounts for 8.5% of total venture capital funding in 2006. The other stages are represented as follows: Early Stage: 30.5%, Mid-Stage: 42%, Late Stage: 19%.

It is estimated that there are now 80 Israeli VC funds with over $10 billion under management. Notable Israeli VC firms include, Gemini Pitango, Veritas and Vertex (51% Singapore-owned). Additionally, several US firms maintain operations in Israel, including Apax Partners and Sequoia Capital, two of the largest US firms. California has played a special role in the development of Israel's high-tech sector with much of the FDI, VC and human talent coming from the state. California firms and policymakers should continue to build on these relationships in order to maintain and extend its access to Israeli innovation.

Israeli Business Clusters relevant to the California Innovation Corridor:

➢ **Biotech/Pharmaceuticals**

Several successful therapies have been developed from research performed at Israeli universities. The following drugs were developed through Yeda Research and Development Company. the commercial arm of the Weitzman Institute of Science. Their success has increased both the size if the life sciences industry in Israel and links to firms in other leading markets such as the U.S. and Europe.

Copaxone: Copaxone was the first innovative drug to be developed in Israel and to receive FDA approval. It is a unique multiple sclerosis immunomodulator and is the first and only non-interferon agent for the treatment of relapsing-remitting multiple sclerosis. Copaxone is licensed to Teva Pharmaceuticals Ltd. To date this drug has had sales of over $1.2 billion.

Frone: (Native interferon beta), is licensed to Inter-Lab Ltd., a Serano company, and is used as an antiviral and anti-cancer drug, and had sales that exceeded 40$ million. It was replaced by Rebif.

Rebif (Recombinant interferon beta) is identical to the native molecule and is registered for the treatment of multiple sclerosis and several viral diseases. It is licensed to Inter-Lab Ltd., a Serano company. To date this drug has had sales of over $1.3 billion.

➢ **Defense** Like California, Israel has a strong defense industry. It is dominated by a few firms, including Israel Aerospace Industries (IAI). While the firm is owned by the state, it has established itself as a leader in several areas including electronics and business jets, in addition to products for both the Israeli military and for export.

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Sources: Technion; Nature Biotechnology, April 2006

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Korea

Overview of Korea's Innovation Infrastructure

Basic Statistics

- ***Population:*** *49.0 million*
- ***Per Capita GDP****: $24,500 (PPP)*
- ***Unemployment Rate****: 3.3%*
- ***Primary Business Locations****: Seoul, Busan, Incheon, Daegu, Gwangju, Daejeon*

Key Assets

Innovation Base: Korea has an extensive university system, with a wide variety of state and private universities. Leading research universities include Seoul National University and Pohang University of Science and Technology. Universities are supported by 150 Centers of Excellence, including Science and Engineering Research Centers, Medical Science Research Centers, and National Core Research Centers, which promote cooperative research between regional universities and local industries. Finally, large private firms perform a significant amount of research, accounting for about three-fourths of research expenditures in 2006.

Industry Base: Strong industry clusters in Electronics, Telecommunications, IT, and Biotechnology. Firms include: Samsung, Hyundai, LG Electronics, KT Corporation, Celltrion, and ViroMed.

Workforce: Korea has made vast improvements in its education system and educational attainment has risen dramatically. Currently, just over 30% of 25-34 year-olds have a university degree, compared with the previous generation (55-64 year-olds) in which just 9% hold a university degree.

Global Recognition: Enabled by the highest broadband penetration in the world, Korea is emerging as a world leader in electronics, IT and pharmaceuticals. It is currently the twelfth largest economy in the world.

Successes in Innovation

Korea has grown tremendously since the 1950s, and it emerged as the world's tenth largest economy in 2005 (12th in 2006). Development has always been structured by government policy, taking a variety of forms from strong export-led growth in the 1960s and 1970s to the expansion of technology-intensive industries in the 1990s. Following the financial crisis in 1997 and the subsequent structural reforms, Korea has moved towards a knowledge-based economy. To this end, the Korean government launched **Vision 2025**, a comprehensive plan to improve scientific and technological competitiveness in Korea to a level comparable to G-7 nations. This three part plan draws on a variety of programs that promote science and technology, improve research infrastructure, and increase manpower.

Investment in R&D

Korea's annual R&D investment was estimated to be around $19B in 2004 or 2.8% of its GDP. R&D investment has grown strongly over the past decade, with 2004 investment 135% higher than 1995. Investment is led by industry, which contributes about 75% of R&D funding. While much of the research effort is directed by large multinationals, SMEs have become increasingly active, and their share in total R&D expenditures has doubled from 11.6% in 1995 to 23.6% in 2004.

Challenges to Continued Innovation

Innovation in Korea may be limited by weak ties between industry and universities/research institutions as well as a low research capacity in general science (over-emphasis in research on applications and outputs).

Example Economic Development Strategies / Programs

U-Korea IT839: The U-Korea, or Ubiquitous Korea, IT839 strategy is designed to promote a digital society in Korea. It seeks to develop and release eight new IT services, three infrastructure networks, and nine future growth engine industries (software and components). Estimated to cost around $70 billion, this strategy is intended to grow the relevant IT industries 15% by 2010. It is expected to increase connectivity, explore the software sector, and promote convergence between IT and other sectors. Since the program's start in 2004, 12 global IT firms have established local R&D facilities in Korea.

21st Century Science Program: This program supports the development of high-tech products that are capable of contributing to national competitiveness within ten years. Projects are provided with $8 to 10 million annually for up to ten years. Since the program's conception in 1999, between 16 and 19 projects have been supported annually.

National Laboratory Research Program: This program identifies and cultivates laboratories in fields of core technologies that will play a pivotal role in improving national competitiveness. Each selected lab is provided $200,000 a year for five years. So far, over 444 laboratories have been supported: 278 universities, 114 research institutes, and 50 affiliated directly with industry.

Daedeok Innipolis: Containing nearly 10% of the Korea's research power, the Innipolis is a mass of 56 publicly funded research complexes and universities. Built in 1974, this science town has been key in facilitating cooperation between private and public institutions. The number of spin-offs ventures created in Daedeok has grown from 40 in 1995 to over 200 in 2005, with 45% in the IT sector and 15% in biotech.

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Sources: OECD, CIA World Fact Book, EU Innovation Trend Chart report (2006), "South Korea Comes of Age" (Demos publication), Ministry of Science and Technology, KOSEF (Korea Science and Engineering Foundation)

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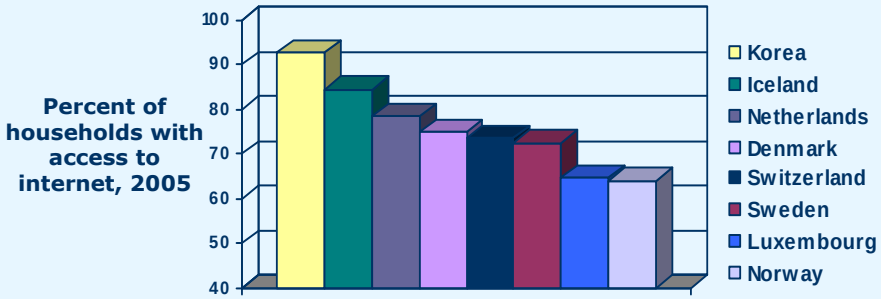
Top Countries for Internet Access



Source: OECD

➢International Collaboration as an Innovation Driver

Until the 1980s, Korea's international collaboration was geared towards promoting the transfer of foreign technologies and gaining the technological know-how to operate the technologies it acquired. As the country continued to gain knowledge and expertise, it began to play a more active role in the development of new technologies. Launched in 1985, the International Joint Research Program has generated a significant amount of bilateral and multi-lateral research activity, funding almost 1,900 projects with 43 countries in the past twenty years. While much of the collaboration is concentrated in a limited number of countries like the U.S., Japan, China, Germany, and the U.K., Korea is seeking to extend its cooperation in the coming years to include a greater variety of partners. Collaboration has included joint research projects and initiatives as well as networking and scientist exchange programs. Joint international publishing accounts for nearly thirty percent of Korean research publishing. The annual budget for international collaboration at the Korean Science and Engineering Foundation, the primary recipient of public funding for scientific research, was $1.3 billion in 2006. Moreover, nearly 10 percent of Koreans live abroad and provide links to other innovation systems. Many successful innovations have resulted from joint collaboration ventures. These include the pioneering of CDMA cellular technology that was developed through an alliance between U.S. company Qualcomm and the Korean Telecom Freetel, and WiBro, a wireless broadband internet technology developed in cooperation with Intel.

Korean Business Clusters relevant to the California Innovation Corridor:

- **Telecommunications**
  Korea has experienced an explosion in the telecommunications industry as a result of continued expansion of the Code Division Multiple Access (CDMA) technology, which has become the core technology for Korean telecom networks. An estimated 79.4% of the population subscribes to some form of CDMA services, and Korea currently has the widest broadband penetration in the world. Korean Telecomm (KT) Corporation is the dominant phone and broadband service provider while SK Telecom leads the mobile market with innovations in CDMA cellular systems. Both companies are publicly traded in the U.S. In addition, LG TeleCom is emerging as a leader in wireless technology with several innovations including the development of Java Station (a Java technology for mobile phones), the pioneering of an electronic system for the payment of public transportation fees by mobile phones, and an infrared payment service that allows credit card payments by mobile phones.
- **Electronics**
  Samsung Electronics has become a world leader in consumer electronics, with a market capitalization of over $100 billion. It was ranked the ninth highest company in the world in R&D spending, with $5.4 billion invested in 2005. It plans to open a new $17.2 billion LCD complex in Tangjeong, which will be the largest LCD complex in world.
- **Biotech/Pharmaceuticals**
  The Korean pharmaceutical market is the tenth largest in the world. This quickly growing industry includes over 600 start-ups as well as a variety of larger firms and joint venture companies. ViroMed is known for its high quality clinical trials, and it initiated Korea's first gene therapy trial in 2001. Leading biopharmaceutical company Celltrion, a joint venture between Korean investors and California-based VaxGen, has established the largest biopharmaceutical facility in Asia, which will specialize in the production of vaccines and recumbent therapeutic proteins.

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Sources: OECD; "South Korea Comes of Age" (Demos publication); Ministry of Science and Technology; Samsung Electronics; LG Telecom; Bio-Europe

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Brazil

Overview of Brazil's Innovation Infrastructure

Basic Statistics

- ***Population:*** *190.0 million*
- ***Per Capita GDP:*** *$8,800 (PPP)*
- ***Unemployment Rate:*** *9.6%*
- ***Primary Business Locations:*** *Sao Paulo, Rio de Janeiro, Salvador, Brasilia, Curitiba, Manaus*

Key Assets

Innovation Base: Brazil has a large university system that includes over 150 private and public universities. Most of the 32 research universities are federally supported, with six universities specializing in fields such as engineering, medicine, and earth sciences. The University of Sao Paulo is recognized as the top research university. Fundação Getúlio Vargas is one of the nation's top schools of business and public policy. Universities are supported by a strong network of research institutes such as the Institute Tecnologico de Aeronautica, known for graduating high quality aeronautic engineers.

Industry Base: Brazil has developed a strong diversified economy that is currently ranked the 9th largest in the world. Strong industry clusters include aerospace, chemicals and IT. National champions in these industries include Petrobras, Electrobras, and Brasil Telecom. Additionally Brazil has developed a strong financial services sector which includes Banco Bradesco, Banco do Brasil, Banco Itau and Unibanco.

Workforce: Brazil has greatly improved and expanded its education system over the last several decades. The number of doctoral degrees has increased significantly in the past ten years from only 1,792 in 1993 to 8,094 in 2003.

Global Recognition: Brazil is recognized as a world leader in aerospace and defense industries, and it is home to the world's third largest Aerospace company, Embraer, a leader in commercial and military aircrafts. Increasingly Brazil has been looked to for its long standing support for the research and production of biofuels.

Historical Context for Innovation

Brazil was colonized by Portugal in the early 16th Century and was treated primarily as a source for raw materials. Over the next several centuries the economy was dominated by a limited number of export products, including sugar, minerals and coffee. Limited by the Portuguese authorities manufacturing did not develop until later in the 19th Century-well after many other nations. Education in Brazil was also late to develop. While schools for training in specific disciplines such as medicine and law were established in the early 19th Century, it was not until 1920 that Brazil's first university, Universidade de Rio de Janeiro, was established. Brazil was ruled by the military from 1964-1985 during which time the military was used as a conduit for economic development.

Investment in R&D

Brazil's annual R&D investment has remained constant over the past decade, estimated to be around 0.8% of GDP in 2002. The majority of investment is made by the government. Around 70% of R&D in 2002 was performed by public research organizations, and the remaining 30% was attributed to industry, with significant support from the government.

Challenges to Continued Innovation

Several challenges remain for Brazil in its efforts to continue to promote technological innovation, especially as a means for social development. These include a relatively high cost for capital (the benchmark interest rate is 12.5%), limited quality education and lack of significant private sector-driven innovation.

Example Economic Development Strategies / Programs

BNDES The Brazilian Development Bank, known by its Portuguese acronym BNDES, is the primary economic development agency in the country. It was established in 1952 and it exercises a great deal of influence over credit in Brazil with profits in 2006 of R$6.331 billion ($3.1 billion). BNDES coordinates several programs that promote the development of innovation in the country including **PROFARMA**, which promotes the production of pharmaceuticals, and **FUNTTEL**, the Fund for the Technological Development of Telecommunications. **FUNTEC (Technology Fund):** This program supports projects that are of strategic interest for the country in fields such as renewable energy, semiconductors, and pharmaceuticals.

CNPq (National Council for Scientific and Technological Development): This agency, affiliated with the Ministry of Science and Technology, has supported the development of technology in Brazil. Since the 1960's, it has assisted an estimated 20,000 students in receiving a graduate degree.

FINEP: Financiadora de Estudios e Projetos, or Research and Project Financing, serves as the Brazilian Innovation Agency under the Ministry of Science and Technology. It supports the following three essential programs. **PRODENGE:** This program seeks to increase the quality of engineering education, support technology development by engineering companies, and re-train engineers already employed in the industry; **INOVAR:** A six part plan to promote venture capital in Brazil; **PAPPE:** Provides grants to researchers and individuals in small firms for product development. From 2004 to 2005, 537 were provided funding.

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Sources: CIA World Factbook; Hewlet, Dynamics of Imperialism

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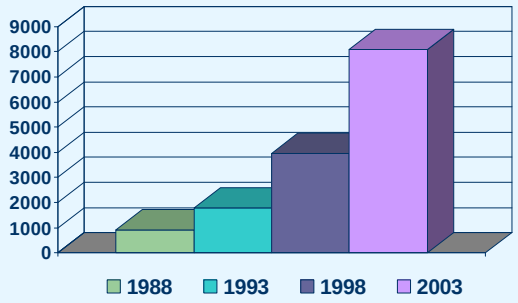
Doctorates Granted in Brazil, 1988-2003



➢Role of Brazilian Education on Innovation

As discussed previously, Brazil had a late start in the development of educational institutions. Recently, however, great strides have been made, especially in the production of a large number of graduate students. The majority of universities, especially those with strong graduate programs, are federally supported. By extension, professors are members of the civil service and are subject to regulations promulgated by government ministries. That has had a two-fold effect: increased personnel costs- resulting in 80-90% of the education budget going towards compensation, and limitations on investigation into innovative fields due to strict guidelines on curricula imposed by the Federal Council of Education. These limitations have lessened with the political and economic liberalization, but still remain, to some extent.

The challenging political environment in Brazil has also contributed to the limits of university-based innovation. Since the 1960s the universities have been opened up to non-elites and university students focused much of their energies on social development, rather than technological development, especially under the Brazilian dictatorship.

The government has recognized these deficiencies and is looking to develop better linkages between universities and government research centers with industry. Additionally, due to limited state budgets, the private sector needs to boost its investment in research & development to support the efforts of the state.

Brazilian Business Clusters relevant to the California Innovation Corridor:

- **Clean Tech/ Biofuels-** The production of sugar was one of the first drivers of the Brazilian economy. In recent years extensive subsidies have been granted towards the development of sugar cane-derived biofuels, and these biofuels currently supply 40% of Brazil's domestic vehicle fuel needs. While the majority of US Biofuels production is concentrated in the central part of the country, California, with its large agricultural economy, should consider biofuels development as a way to bring innovation to more rural regions of the corridor and create linkages to academic work being done in the state. This includes the recently established $500m Energy Biosciences Institute, co-located at UC Berkley and the University of Illinois and funded by BP, which is set to be one of the world's centers of biofuels research. Additionally, California should look to actively participate in the development of biofuels standards, led by organizations such as the Roundtable on Sustainable Biofuels.
- **Aerospace-** Brazil is home to a strong aerospace industry, which is primarily concentrated in Sao Paulo State. Empresa Brasileira de Aeronáutica S.A, better known as Embraer, has produced aircraft that are used by the military of more than 20 countries and comprise a large segment of the commercial and business jet markets. Its 2005 revenue was over $3.5 billion. Other firms include Avibrás and Helibrás. Brazil has an active space program, directed by the **Agência Espacial Brasileira** and engages in joint technology efforts with other countries, including the US, Israel and China. Much of the expertise for the aerospace industry was developed at the National Institute for Space Research (**INPE**), a unit of the Brazilian Ministry of Science and Technology. Aerospace development was a specific goal of the military dictatorship which led Brazil from 1964-1985. The military's central role in the space sector continues under the **Comando-Geral de Technologia Aerospacial**, Brazilian General Command for Aerospace Technology, which is responsible for the coordination of research around this area.

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Sources: Washington Post "Building a Biofuels Alliance", SF Chronicle "Cal to be hub for study of alternate fuel, Aerospace Industries Association of Brazil, "Brazil", Encyclopedia of Higher Education

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Funding provided by Department of Labor, Employment & Training Administration: WIRED Initiative