Professor Michael E. Porter, Harvard University
Council on Competitiveness
Monitor Group
ontheFRONTIER

San Diego

CLUSTERS OF INNOVATION INITIATIVE

- ATLANTA
- PITTSBURGH
- RALEIGH-DURHAM
- SAN DIEGO
- WICHITA

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Council on Competitiveness
1500 K Street, NW
Suite 850
Washington, DC 20005

Tel: (202) 862-4292
Fax: (202) 682-5150
Email: council@compete.org

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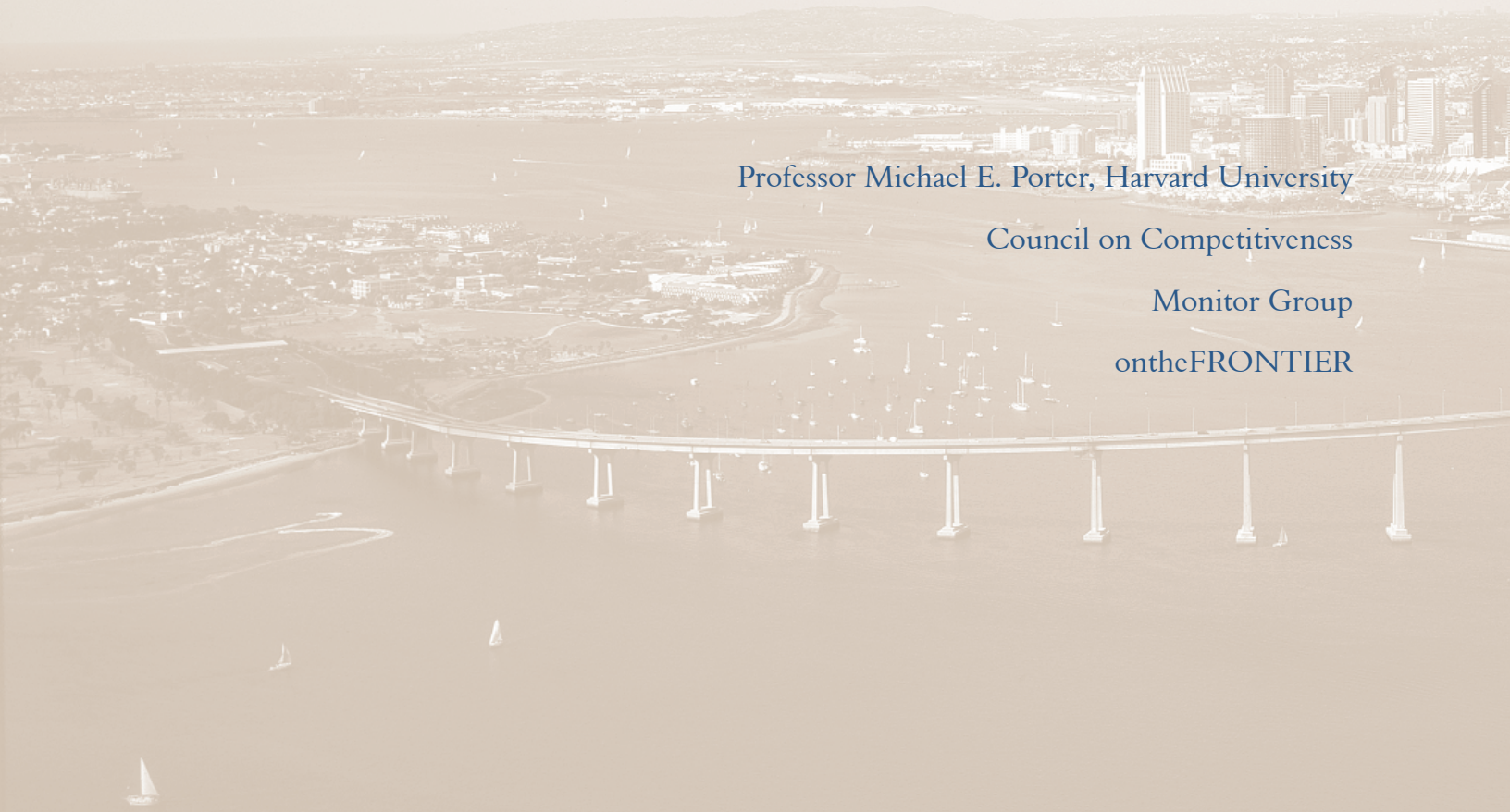

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CLUSTERS OF INNOVATION INITIATIVE: SAN DIEGO

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Chairman's Foreword

Regional economies are the building blocks of U.S. competitiveness. The nation's ability to produce high-value products and services depends on the creation and strengthening of regional clusters of industries that become hubs of innovation. We are developing a better understanding of how these clusters raise productivity and are able to innovate more rapidly due to the ability to bring together technology, resources, information, and talent among companies, academic institutions, and other organizations. Close proximity, and the accompanying tight linkages, yields better market insights, more refined research agendas, larger pools of specialized talent, and faster deployment of new knowledge.

Utilizing a unique database developed at the Institute for Strategy and Competitiveness at the Harvard Business School, we are able to measure the relative strength of regional clusters and track their economic and innovation performance over time. In addition, professionals at the Council on Competitiveness, Monitor Group and its affiliate ontheFRONTIER, and the Institute conducted surveys, interviews and analyses in order to assess the strengths and challenges of the regional economies and selected clusters in San Diego, Atlanta, Pittsburgh, the Research Triangle in North Carolina, and Wichita.

We are pleased to present this report on San Diego — the first of five reports on pilot regions. The study contains a conceptual framework for assessing the competitiveness of regional economies, an analysis of the San Diego region overall, as well as detailed assessments of two representative clusters — biotechnology/pharmaceuticals and communications. The report outlines the accomplishments, lessons learned, challenges, and opportunities for San Diego. These findings will be integrated into a national report to inform both the public and private sector of new strategies used for regional economic development and cluster upgrading. The report will be released at the National Clusters of Innovation Conference on December 13, 2001 in Washington, DC.

We wish to acknowledge the tremendous support we received from the San Diego community with particular thanks to our local advisors, Irwin Jacobs, Duane Roth, Julie Meier Wright and Bob Dynes. Many of you have helped us to create a unique knowledge base about your region, its industries and its organizations. Your thoughts and insights are embedded in this report, and will benefit not only San Diego but other parts of the country.

Sincerely,

F. Duane Ackerman
Co-Chair, Clusters of Innovation Initiative
Chairman & CEO, BellSouth Corporation

Michael E. Porter
Co-Chair, Clusters of Innovation Initiative
Bishop William Lawrence University Professor,
Harvard Business School

INTRODUCTION

About the Clusters of Innovation Initiative

Future U.S. competitiveness will hinge on our capacity to foster clusters of innovation in regions throughout the country. The clusters of innovation concept represents a new way of thinking about the economy and has begun to take hold as communities across the nation look at the successes of California's Silicon Valley and Massachusetts' Route 128. It is regions such as these, containing many vibrant clusters, that drive the U.S. economy. The nation's ability to produce high-value products and services that support high wage jobs depends on the creation and strengthening of many more regional hubs of innovation.

The Clusters of Innovation Initiative was launched to help meet this challenge. Under the leadership of Professor Michael Porter, Harvard University, and Duane Ackerman, Chairman and CEO of BellSouth, and guided by a steering committee of national leaders, the Initiative aims to understand how clusters develop within a regional economy, and to use these lessons to inform key decision makers in every part of the country.

The Initiative benefits greatly from a partnership of the Cluster Mapping Project at the Institute for Strategy and Competitiveness at Harvard Business School, the Council on Competitiveness, and the Monitor Group and its affiliate, on theFRONTIER. The Cluster Mapping Project has created a detailed statistical analysis of county-level business data that defines 40 types of clusters (e.g., information technology, automotive, business services) that are found in regions throughout the U.S. economy and maps regional economies by cluster and constituent industry. The data also includes detailed metrics on employment, average wages, new establishment formation and patenting, thus enabling rigorous analysis of the comparative economic performance of regions and their clusters.

In addition to the Mapping Project, professionals from the Council, Monitor Group, and ontheFRONTIER are using a broad-reaching survey — The Clusters of Innovation Initiative Regional Survey — and in-depth interviews to study the historical growth and current performance and composition of local economies and selected clusters in regions around the country: Atlanta/Columbus, GA; Pittsburgh, PA; Raleigh/Durham/Chapel Hill, NC (Research Triangle); San Diego, CA; and Wichita, KS. In San Diego, 232 executives were surveyed, and another 50 were interviewed. By using a common methodology and drawing on comparable data, we are able to make valid comparisons across regions and clusters, to learn what factors drive cluster development and economic performance, and draw lessons to inform both public and private action agendas.

San Diego

This report on San Diego is the first of the five regional reports to be completed this year. San Diego was chosen as a pilot region because of the way it reduced its dependence on tourism and defense aerospace to emerge from a deep recession over a decade ago to become one of the nation's fastest growing, diverse economic regions. Significant investment in research and development; important formal and informal connective institutions among industry and academia and government; and the vision, entrepreneurial spirit, and concerted action of business and government leaders enabled San Diego to develop this economic diversity and attain competitive positions in clusters such as communications and biotechnology/pharmaceuticals.

Organization of the Report

This report is divided into five sections:

- **Section 1** provides an overview of the determinants of regional competitiveness and innovative capacity.
- **Section 2** outlines a methodology for assessing them.
- **Section 3** applies this model of regional competitiveness to San Diego. It examines the overall performance and composition of the San Diegan economy, and describes how San Diego transformed its economy over the course of the 20th century.
- **Section 4** examines the history, competitive position, and performance of selected clusters—biotechnology/pharmaceuticals and communications—in the region.
- **Section 5** draws from the regional and cluster analyses to identify lessons, challenges, and opportunities that will inform the national Clusters of Innovation Initiative.

The development of specific recommendations and action plans is beyond the scope of this report. Nevertheless, it does provide many high-level recommendations, including several new strategic directions to pursue, challenges to overcome, and opportunities to seize in order for San Diego to sustain its competitive position and performance going forward.

The National Clusters of Innovation Conference

The findings of this report and those from the other pilot regions will be presented at a National Clusters of Innovation Conference to be convened this December in Washington, D.C. by the Council on Competitiveness. These findings will provide the analytical basis for this conference and other initiatives to create and support high-performing industries and sustain our nation's competitiveness and prosperity.

ACKNOWLEDGMENTS

The James Irvine Foundation, the Jacobs Family Philanthropic Fund, and QUALCOMM, Inc. generously provided underwriting for this report.

This report benefits from the leadership of Professor Michael Porter of Harvard University, Duane Ackerman of BellSouth Corporation, and the efforts of professionals from the Harvard Business School Cluster Mapping Project, Monitor Group and its affiliate, ontheFRONTIER, and the Council on Competitiveness.

Elizabeth de Fontenay, Veronica Ingham, Christian Ketels, Daniel Vasquez, Weifeng Weng, and Harvard Business School Cluster Mapping Project provided extensive regional and industry cluster data for this report.

Randall Kempner, ontheFRONTIER, and Kurt Dassel, Monitor Group, were the report's principal authors. Mark Fuller and Jeff Grogan of the Monitor Group provided overall project direction and editorial advice.

John Yochelson and Alan Magazine at the Council on Competitiveness provided project oversight and interface with business and government leaders in San Diego. Michelle Lennihan coordinated the field-work, performed data analysis, and gave general project direction. Jackie Mathewson and Debra VanOpstal provided additional national economic data and analysis, as well as ongoing review and critique of the project.

Robert Dynes, University of California, San Diego, Irwin Jacobs, QUALCOMM, Incorporated, Duane Roth, Alliance Pharmaceutical Corp, and Julie Meier Wright, San Diego Regional Economic Development Corporation, reviewed and commented on drafts of this report and served as advisors to the project.

Several individuals from the University of California, San Diego, provided valuable assistance to the project: Ed Furtek and Susanne Huttner helped with numerous interviews of government and business leaders in San Diego; Associate Vice Chancellor Mary Walshok reviewed and commented on drafts of this report; and Sara Burke greatly assisted with the dissemination of the Clusters of Innovation Initiative Regional Survey.

Pat Windham, a private consultant, assisted with interviews of community and business leaders. MarketTools, Inc., provided the project with an on-line survey capability; and Sarah Brunton, Alliance Pharmaceutical Corp, helped coordinate interviews and surveys in San Diego. Joe Panetta, BIOCOM, provided important background information and made helpful suggestions.

Lily Rappoli and her colleagues at the Design Studio at Monitor Group illustrated, designed, and created the layout of the report.

More than 250 business and government leaders contributed to this project in some way by providing background information, granting U.S. interviews, completing surveys, and offering helpful suggestions. While the report tries to reflect the consensus view of those interviewed and surveyed, it also attempts to be concise. Any errors, omissions, or inconsistencies are the responsibility of the report writers and not any one individual or institution.

For additional information on this research, contact Kurt Dassel at Monitor Group (e-mail: Kurt_Dassel@Monitor.com), Randall Kempner at ontheFRONTIER (e-mail: Randall_Kempner@onthe-frontier.com), or Michelle Lennihan at the Council on Competitiveness (e-mail: Lennihan@compete.org).

CLUSTERS OF INNOVATION

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San Diego Regional Advisors

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Duane Roth, *Alliance Pharmaceutical Corp.*
Julie Meier Wright, *San Diego Regional Economic Development Corp.*

HIGHLIGHTS OF THE CLUSTERS OF INNOVATION INITIATIVE REPORT ON SAN DIEGO

Regional Competitiveness and Innovative Capacity

- The economic goal for San Diego should be a high and rising standard of living.
- This depends upon creating a high quality business environment which fosters innovation and rising productivity.
- Strong and competitive clusters are a critical component of a good business environment, and are the driving force behind innovation and rising productivity in a region.
- All levels of government can influence the business environment and the productivity of clusters.
- While government can help foster a favorable business environment, companies and industries must ultimately achieve and sustain competitive advantage.
- Formal and informal institutions for collaboration such as regional economic development organizations and alumni of large influential companies are important contributors to cooperation in advanced economies.

San Diego's Successes Over the Past Decade

- San Diego outpaced the nation in terms of job creation, productivity, and exports.
- Patents per worker grew to more than twice the national average.
- Venture capital funding per worker is nearly three times the national average.
- The region outperformed the nation in terms of fast-growth firms.
- San Diego transformed its economy from one highly dependent upon the military, defense/aerospace, and tourism to one that is knowledge based.

Strengths

- San Diego is rich in highly regarded educational and research institutions, especially in the biosciences.
- It has a strong record of attracting federal research dollars and state-funded university support.
- Historically, San Diego has benefited greatly from a large pool of scientists, engineers, and skilled technicians.
- The metro area has numerous strong and growing clusters.
- Local government has historically played an important role in fostering a favorable business environment.
- The formal and informal collaborative institutions have been important catalysts for growth.
- San Diego's location and climate have attracted talented workers, and have had an important contribution to the region's standard of living.

The Need for New Directions

- San Diego's new challenge is not just to create jobs, but create high paying jobs.
- Clusters in the region need more strength across buyer and supplier networks, and in specialized training institutions.
- Companies must become more central to the innovation process.
- Growing "high tech" clusters alone will not suffice to yield an economy with high wages relative to other regions. San Diego must support innovation and upgrading across all clusters.
- New types of cluster-specific collaborative institutions will be needed.

Challenges

- Citizens of San Diego have wages at the national average but face a cost of living above the national average, which is an economic burden to its citizens and makes it more difficult to recruit talent.
- Rapid economic and population growth have put a strain on the region's physical infrastructure, which degrades business efficiency and the regional quality of life.
- San Diego needs to develop a strategy to redefine and upgrade its quality of life.
- The regional economy faces current or imminent shortages in the supply of marketing and management professionals, scientists, engineers, and skilled labor.
- Clusters in San Diego need to build strength in all four determinants of innovative capacity: specialized inputs, related and supporting industries, context for firm strategy and rivalry, and demand conditions.
- The current capacity of institutions for collaboration will likely prove insufficient in the future.
- Solving many of these challenges will require greater coordination among governmental jurisdictions in the metropolitan area.

Opportunities

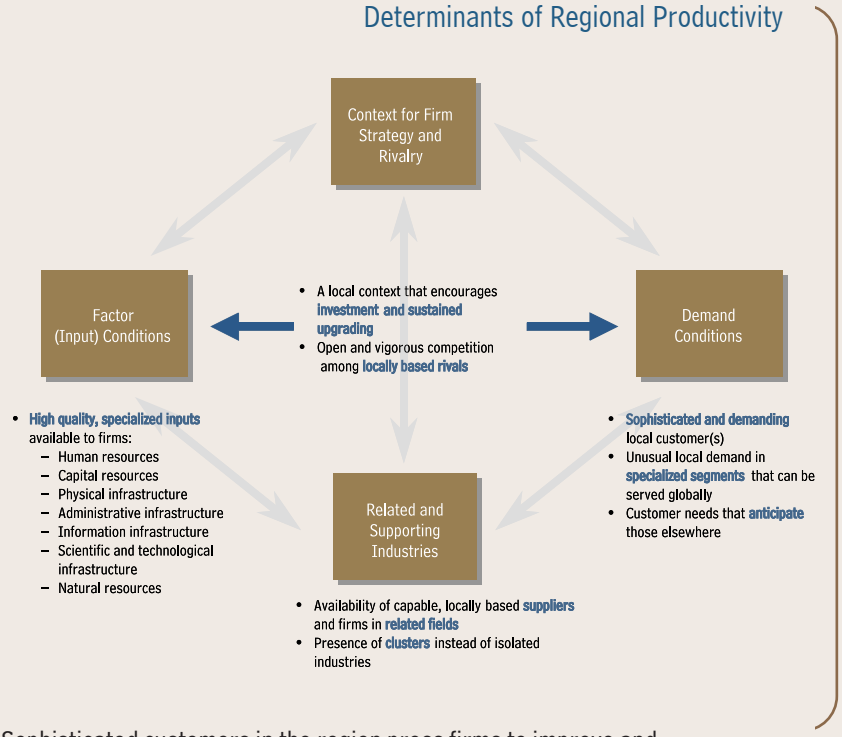
- San Diego has a large number of strong clusters and has the opportunity to support innovation across all of them, not just the "high tech" clusters it tends to favor.
- San Diego was, is, and will always be a Navy town; the military presence offers opportunities for spin-offs from ongoing military research.
- San Diego's firms and non-commercial organizations are not thinking hard enough about how to benefit from the close proximity of Mexico.
- San Diego institutions should break out of their "vertical silos" and embrace cross-cluster initiatives to foster the growth of new clusters and subclusters.

EXECUTIVE SUMMARY

The Determinants of Regional Competitiveness and Innovative Capacity

The central economic goal for San Diego should be to attain and sustain a high and rising standard of living for its citizens. The ability to earn a high and rising standard of living depends on increasing productivity which in turn depends on innovation. The central challenge then in enhancing prosperity is to create the conditions for sustained innovation output.

A critical driver of innovation output is the quality of the regional business environment in which firms operate. This environment is embodied in four broad areas that affect the productivity that can be achieved as well as the rate of innovation.



- **Factor conditions.** Achieving high levels of innovation and productivity growth depends on the presence of high quality and specialized pools of human resources, applied technology, infrastructure, and even sources of capital that are tailored to the needs of particular industries.
- **Demand conditions.** The quality of demand at home has a strong influence on the process of creating and improving products and services. Sophisticated customers in the region press firms to improve and offer insights into existing and future customer needs.
- **Context for firm strategy and rivalry.** The rules, incentives, and pressures governing the type and intensity of local rivalry have a fundamental influence on productivity policies that encourage investment, protect intellectual property, and foster productivity growth.
- **Related and supporting industries.** Local sourcing from capable suppliers based in the region can enhance productivity and improve the capacity for innovation through allowing quicker and less costly communication fostering the flow of ideas and enhancing flexibility through outsourcing.

These four areas of the diamond shown above are self-reinforcing and act as a system. Regional rivalry, for example, stimulates the development of unique pools of specialized skills and the formation or attraction of specialized suppliers. Active local rivalry also upgrades regional demand by creating more demanding customers.

Clusters and Productivity

The workings of these attributes lead to the formation of clusters, or geographically proximate groups of interconnected companies and associated institutions in a particular field, linked by customer, supplier, or other relationships.

Once a cluster forms, the industries that constitute it become mutually reinforcing. Information flows freely, and innovation spreads rapidly through the relationships among customers and suppliers. Institutions such as colleges and universities adapt to cluster needs. Rivalry in one industry spreads to other industries in the cluster through spin-offs or related diversification.

Through a cumulative process that often occurs over several decades, the region becomes a repository of specialized expertise, technology, and institutions for competing in a given field.

Clusters innovate faster because they draw on local networks that link technology, resources, information, and talent. Strong competitive local pressures increase incentives for a cluster participant to innovate. Clusters build the basis for specialized skills and capabilities and enable competitive advantage in world markets.

The Role of Government in Competitiveness

Government at all levels has an influence on the business environment and the innovative potential of clusters. Government's proper role is to improve the business environment rather than to intervene directly in the competitive process.

Government has four fundamental roles:

- Improve the quality of basic inputs that firms draw upon, such as human resources, physical and technological infrastructure, and capital;
- Create rules, regulations, and incentives that encourage innovation and upgrading. Through regulations, tax policy, and antitrust enforcement, government policies influence the climate in which firms compete;
- Build upon and reinforce the formation of local clusters; and
- Raise the sights of local firms and the region's citizens—helping to educate about the imperative of international competition, articulating an economic vision for the region, signalling the future, and so forth.

Institutions of Collaboration in San Diego

Institutions for Collaboration

Companies can invest to upgrade the local environment individually and through industry associations and other institutions for collaboration. These are formal and informal organizations and networks that (1) facilitate the exchange of information and technology; and (2) foster various kinds of coordination and collaboration that can improve the business environment in a cluster or in the overall economy.

THE COMPOSITION OF REGIONAL ECONOMIES

Regional economies are composed of four main types of activities:

- **Local clusters.** These clusters are found everywhere and produce goods and services which are needed by the local population (e.g., retail trade).
- **Traded clusters.** Traded clusters produce goods and services in a particular locale, and then distribute that product across the nation or globe (e.g., automotive, medical devices). These clusters are concentrated only in a handful of regions.
- **Natural resource clusters.** Natural resource clusters are found in locations where a particular natural resources is abundant; they are there to extract and distribute that resource.
- **Local operations of clusters based elsewhere.** These are not research, manufacturing, or other knowledge-intensive activities, but those involved in marketing and distribution.

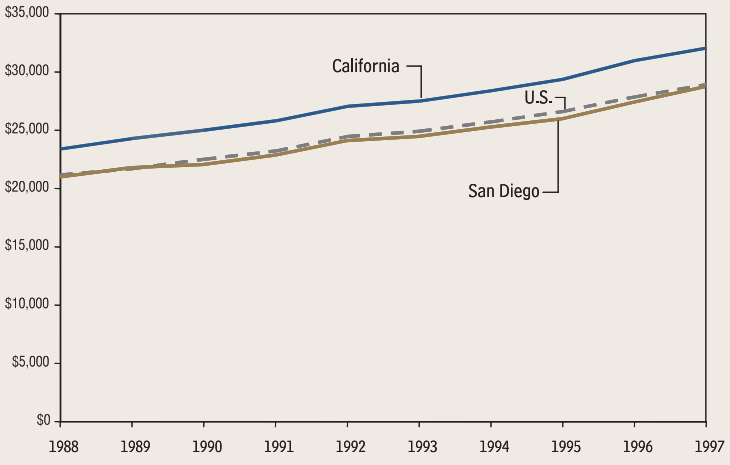
Traded clusters drive regional prosperity. While local clusters account for roughly two-thirds of employment in an average region, traded clusters heavily drive the prosperity and growth of a region; average wages in traded clusters are roughly $13,000 a year higher than wages in local clusters. This is because traded clusters can achieve higher productivity, their growth is unconstrained by the size of the local markets, and their success creates much of the demand for local clusters.

PERFORMANCE AND COMPOSITION OF THE SAN DIEGO ECONOMY

Overall Economic Performance Indicators

- **Employment.** San Diego paced the nation in terms of job creation over the last decade, and the region grew faster than California overall. Employment in San Diego 1999 was 1.36 million; up from 1.15 million in 1990.
- **Unemployment.** Unemployment in San Diego dropped from a high of 7.7% in 1993 to 3.1% in 1999, below both California's rate of 5.2% and the nation's rate of 4.2%. Unemployment rates in 1999 for benchmark regions were 2.2% in Boston, and 3.0% for San Jose.
- **Wages.** In 1997, average wages in San Diego were $28,855, below both the national average of $28,945 and the California average of $32,089. Average wages in 1997 for select benchmark regions were $29,450 for Austin, $33,901 for Boston, and $47,368 for San Jose.

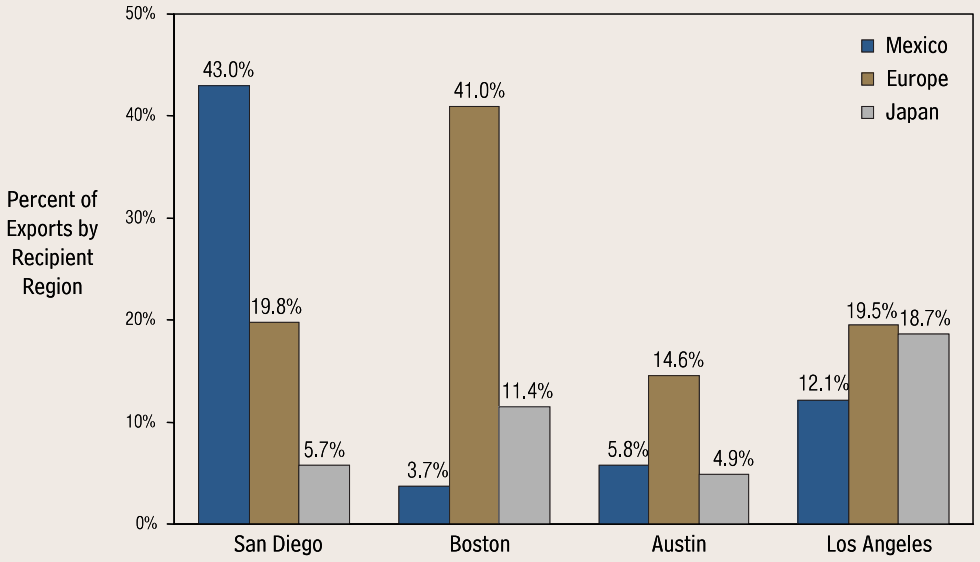
Average Wages in Select Geographic Areas



Note: Average wages are nominal
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

- **Cost of living.** The cost of living in San Diego is an estimated 25% higher than the national average. In 1999 housing costs were estimated 50% higher than the national average.
- **Productivity.** The productivity of San Diego's economy slightly exceeds the nation. Its weighted average index is 103.6 or 3.6% greater than the national average. The comparable numbers for benchmark regions are 107 for California, 113 for Boston, and 94 for Austin.
- **Exports.** San Diego exports almost 50% more per worker than the national average, and annual export growth is 60% faster than the nation's. However, much of this is the export of components to Mexico for final assembly.

Manufactured Exports of Select Metropolitan Areas by Destination



Note: Data are for manufactured and commodity exports only
Source: U.S. Department of Commerce, International Trade Administration

Innovative Capacity Indicators

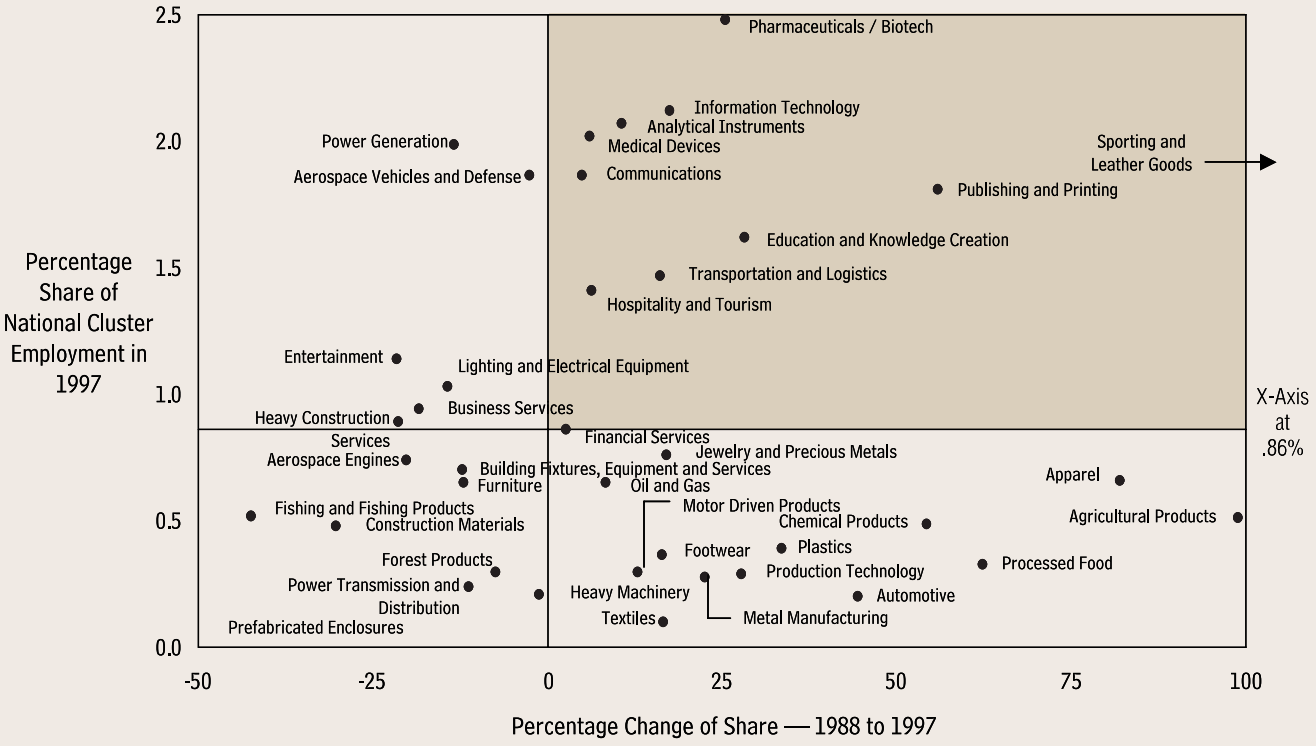
- **Patents.** San Diego produced 12.87 patents per 10,000 workers, more than twice the national average of 6.29, but well behind competitor regions like Boston (20.93) and Austin (22.2). San Diego's annual patent growth rate of 9.67 % was seventh fastest among the 20 largest patenting regions; faster than the national rate of 6.54%, and Boston's rate of 7.11%, but significantly behind Austin's 18.01%.
- **Venture capital investments.** Venture capital funding per worker is nearly three times the national average. But, from 1995 to 1999, San Diego's 35.6% annual growth rate of venture capital investments is below the national average of 54.7%, Boston's growth of 66.7%, and Austin's growth of 85.9%.
- **Fast growth firms.** San Diego has had a disproportionately high percentage of firms on Inc. Magazine's lists of the 500 fastest growing companies in the nation.
- **Initial public offerings.** There were 14 initial public offerings (IPOs) in the San Diego region in 1999, up from 4 in the prior year. Nevertheless, top regions like Boston, MA, and San Jose CA produce far more, 46 and 63 respectively.

Composition of the San Diego Regional Economy

- **Traded industry versus local industry employment.** In 1997, 32.4 % of San Diego's employment was in traded clusters such as medical devices and financial services; 66.7 % of San Diego's employment was in local clusters such as personal services, local construction, and real estate development;
  While employment in traded clusters as a percentage of total employment declined during the early to mid 1990s during the defense / aerospace downturn, San Diego has increased its percentage of employment in traded industries since then.

- **Strong positions in numerous clusters.** San Diego enjoys strong positions in numerous clusters, including power generation, aerospace and defense vehicles, biotechnology/pharmaceuticals, communications, information technology, analytical instruments, medical devices, financial services, transportation and logistics, hospitality and tourism, education and knowledge creation, publishing and printing, and sporting and leather goods. Forty-seven percent of San Diego's employment in traded industries are in clusters relatively stronger and more rapidly growing than the national average (i.e., in the upper-right quadrant).

Traded Clusters by Size and Relative Growth Rate

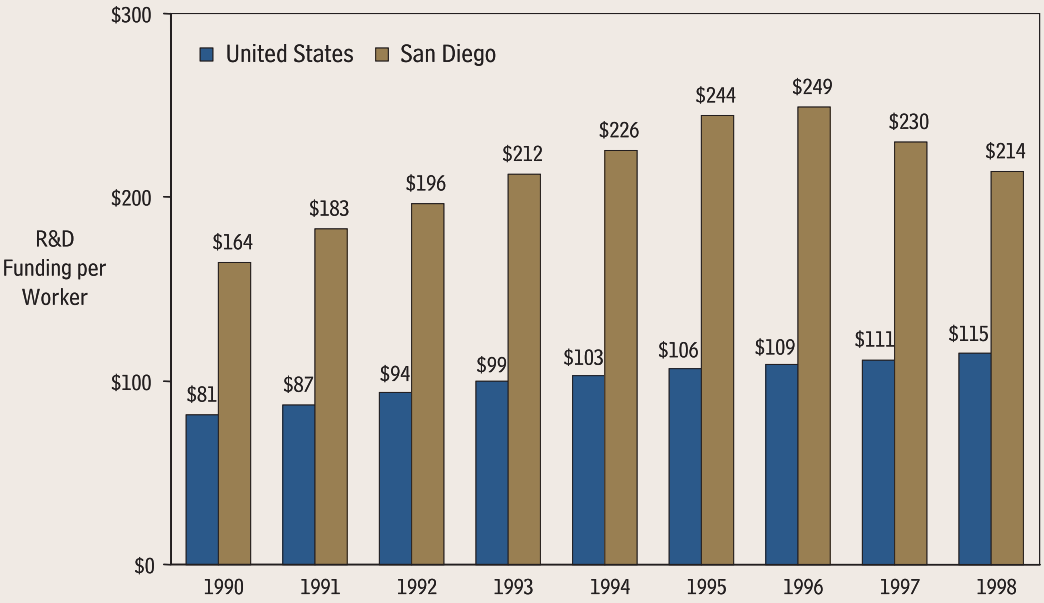


Note: Tier 2 Industries
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

Assessment of Overall Innovative Capacity

- **Strong educational and research capabilities.** San Diego has highly regarded educational, medical and research institutions such as the University of California, San Diego, Salk, Burnham and Scripps Institutes.

Federal Funding for University R&D per Worker, 1990–1998



Source: NSF WebCASPAR Database System, U.S. Bureau of Labor Statistics

- **Highly skilled work force.** These institutions attract a large pool of talented scientists, engineers, students, and skilled labor to the region, a fact that, in turn, has fostered new firms and influenced outside firms to locate there.
- **High levels of federal and state funded research and development.** Talented researchers and aggressive grant seeking have enabled San Diego to be successful in attracting federal research dollars and state funded university support.
- **Strong government support.** Local government has had an important role throughout San Diego's history in encouraging business growth. Local and state efforts brought the military and bioscience research facilities as well as state and federal funded R&D. Sophisticated demand from the Navy served as an important positive influence on the development of wireless communications and the San Diego communications cluster.
- **Strong institutions for collaboration.** Strong formal and informal collaborative institutions involving business, government and academia have facilitated the flow of information, ideas, and resources within and among industry clusters.
- **Good quality of life.** San Diego's location and attractive climate provide an important contribution to the standard of living in San Diego and contribute to attracting scientists, engineers, and highly skilled employees to the region.

While fundamentally strong, the San Diego economy faces some difficult challenges, many of which are the consequence of this success. Nevertheless, if unmet, these challenges could undermine the region's historical bases of strength.

- **Average wages but a higher cost of living.** Average wages in San Diego are just below those of the nation as a whole, while the cost of living in San Diego is significantly higher than the national average.
- **Strain on the physical infrastructure.** Rapid economic and population growth has put a strain on the region's physical infrastructure. A relatively small airport, increasingly congested roads, and a limited supply of energy and water are the most frequently mentioned areas of concern.
- **Concerns about the future supply of scientists, engineers, and skilled labor.** The rapid growth of the San Diego economy over the past decade is leading to the possibility that the region will be unable to replenish its pool of scientists, engineers, and skilled technicians.
- **Need for more management and marketing talent.** Professional management makes up 6.6% of San Diego's workforce, 6.7% of the United States'. Survey respondents and interviewees consistently report that firms must recruit managers and marketers from outside the area.
- **Need for improved university technology transfer offices.** The process of transferring technology from the universities has been described as slow and cumbersome.
- **Need for better government policies and coordination.** State actions contribute to a poor energy infrastructure, average K-12 education, and high costs of building facilities. Local governments' poor coordination makes it difficult to solve infrastructure issues like upgrading roads, schools, and the airport.
- **Exports performance.** Although per capita exports from San Diego exceed that of the nation, the data suggest much of this is export of components to Mexico for final assembly and re-export back to the United States. San Diego firms have yet to establish themselves as strong international competitors.

ASSESSMENT OF THE BIOTECHNOLOGY/PHARMACEUTICAL CLUSTER

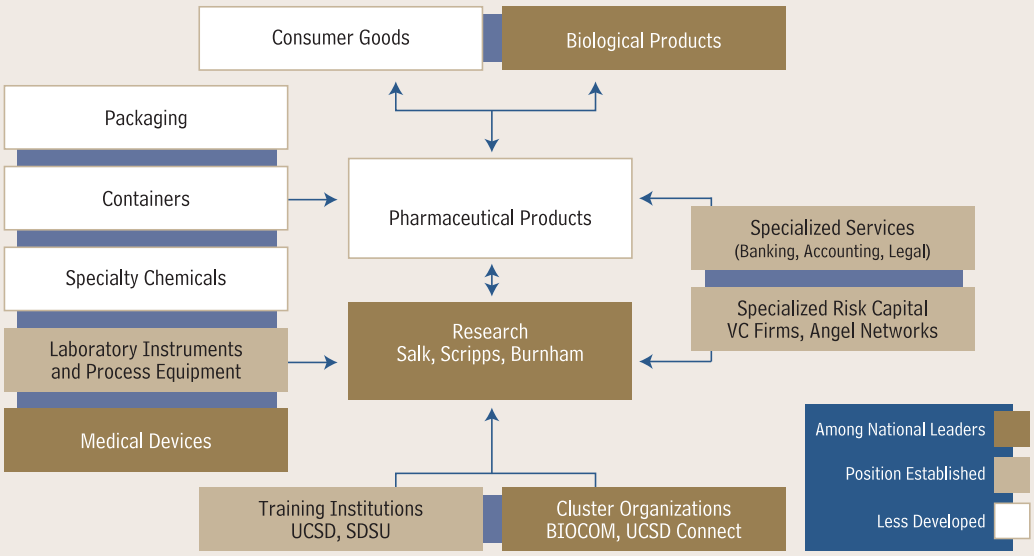
Economic Performance

- **Employment.** The San Diego cluster is the ninth largest in the United States, and is the fifth fastest growing, among the United States' 20 largest clusters.
- **Wages.** Wages paid in the San Diego cluster are above the national average, and are rising faster than the national rate.
- **Patent Registration.** The San Diego cluster registers a disproportionate share of the nation's total biotechnology/pharmaceutical patents and has the fastest patent growth rate among the nation's 20 largest biotechnology/pharmaceutical clusters.

Composition

- The San Diego cluster has strength in biological products and cluster organizations such as BIOCOM and UCSD Connect. It is focused on research and development, and has nationally recognized research institutions such as Salk, Scripps, and Burnham.

San Diego Biotechnology / Pharmaceutical Cluster



Source: Clusters of Innovation Initiative Regional Survey, Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School and Interviews

- The cluster has established national positions in laboratory instruments and process equipment; medical devices; training institutions such as University of California at San Diego (UCSD) and San Diego State University (SDSU); specialized risk capital through venture capital firms and angel networks; and specialized services.
- The cluster has less developed national positions in inputs (e.g., specialty chemicals), and pharmaceutical products, and is just developing local manufacturing.

Innovative Capacity

- **Strengths**
  - High levels of R&D investment.
  - Numerous specialized research and training institutes.
  - High quality of life.
  - Good knowledge transfer from institutes to industry.
  - A large pool of scientists and skilled technicians.
  - BIOCOM, a quality institution for collaboration.
- **Challenges**
  - Lack of local manufacturing facilities and expertise.
  - Underdeveloped relationships with customers and suppliers.
  - Need for consistency between state and federal FDA regulations, and better coordination among local political jurisdictions on solving infrastructure issues.
  - Need for more effective university technology transfer offices.

ASSESSMENT OF THE COMMUNICATIONS CLUSTER

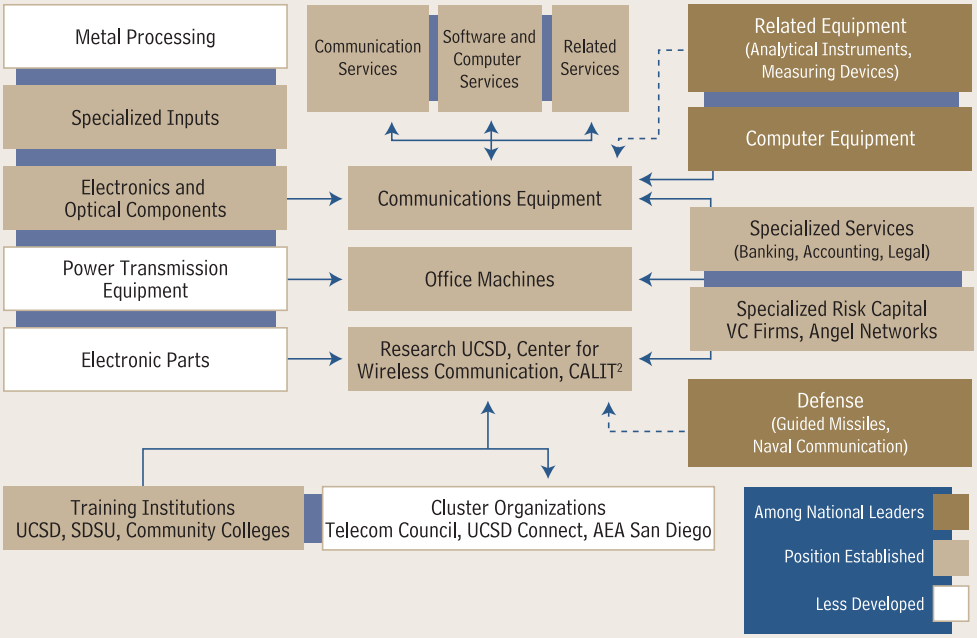
Economic Performance

- **Employment.** In 1997, the San Diego MSA was the eighth largest communications cluster in the country, and the eleventh fastest growing out of the 20 largest clusters in the United States.
- **Wages.** Average wages in the cluster are slightly higher, and are growing slightly faster, than national averages for the communications cluster.
- **Patent Registration.** Out of the 20 largest communications clusters in the country, San Diego ranks tenth in patents per employee, and eighth in annual growth of patenting.

Composition

- The San Diego communications cluster is well represented in all its constituent parts; only three sub-clusters have a relatively small share of national employment.
- The San Diego cluster especially strong in wireless communications research, particularly in code division multiple access (CDMA) technology.

The San Diego Communications Cluster



Source: Clusters of Innovation Initiative Regional Survey, Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School and Interviews

Innovative Capacity

- **Strengths**
  - Relatively large pool of communications-related scientists, engineers, and technicians.
  - Numerous research divisions of major communications firms, such as QUALCOMM, Motorola, Ericsson, Sony, and Nokia.
  - Growth of specialized research institutions, such as the expansion of the UCSD engineering school and the Center for Wireless Communications (CWC) and Cal-IT2, both at UCSD.
  - Federal and state-sponsored research and development investment.
  - Strong local presence in most sub-clusters.
  - Sophisticated local demand for wireless communications.

- **Challenges**
  - Relatively slow and cumbersome technology transfer from universities and research institutes.
  - Diminishing supply of managers, marketers, engineers, and skilled labor.
  - Sporadic cooperation among local firms on technology development and cluster improvement.
  - Underdeveloped relationships with customers and suppliers.
  - Nascent cluster-specific institutions for collaboration not yet established.

SUSTAINING COMPETITIVE ADVANTAGE: LESSONS, CHALLENGES, AND OPPORTUNITIES

San Diego's leaders have accomplished a great deal over the last century. Local government attracted a military presence that spawned numerous business clusters and preserved the region's quality of life. Government and industry attracted bio-science research centers that, again, preserved the quality of life and grew several clusters. University leaders reached out to industry and produced institutions for collaboration that facilitated the flow of research and ideas from the university, and brought scarce local business resources to university-based entrepreneurs. Finally, entrepreneurs built many successful companies.

Lessons

- **Innovation.** The San Diego economy has produced considerable innovation output over the last decade, and this has led to rapid growth. San Diego's most innovative clusters—like sporting and leather goods and medical devices—are among the region's top performers.
- **Traded industries.** Traded industries are key drivers of economic performance. The lower than average wages in San Diego are due to the lower than average employment in traded industries; as regional employment in traded industries rises, so too will average wages.
- **Clusters.** Clusters are another key driver of the performance of a regional economy. When the aerospace and defense cluster in San Diego struggled, so too did the regional economy. As clusters such as education and knowledge creation, business services, and sporting and leather goods grew, the regional economy emerged from recession.
- **Unique assets.** San Diego leaders used and enhanced the assets they had to attract the military, defense firms, and research institutions. Natural endowments were not only useful for the firms, but also led to a high quality of life which attracted talented people.
- **Leadership.** The work of a handful of individuals contributed greatly to the economic development of San Diego. Their efforts created regional strengths that enabled many more to succeed.
- **Sustained commitment.** It took 20 years to build a large military presence, and another 20 years to realize significant development of the clusters that grew from the Navy's research agenda. Similarly, local leaders committed significant resources to assemble a critical mass of bioscience research facilities and institutions, and then waited many years to witness the take-off of the biotech/pharma and medical devices clusters.
- **Diversity of research institutions.** UCSD, Scripps, Salk, Burnham, the CWC, General Atomics, and organizations such as the Navy's Space and Naval Warfare Systems Command (SPAWAR) enable companies to choose from a diverse set of models of how research institutions interact with companies in the region.
- **The value of proximity**. Several interviewees mentioned that the close proximity of research institutions on the mesa encouraged innovation. The success of Research Triangle Park in North Carolina points to the same conclusion.
- **Local businesses, government, and knowledge centers.** When these groups shared a common agenda and all worked to achieve it, they succeeded in bringing the military, bio-science research centers, UCSD, the supercomputer center, and the engineering school to the region. When they

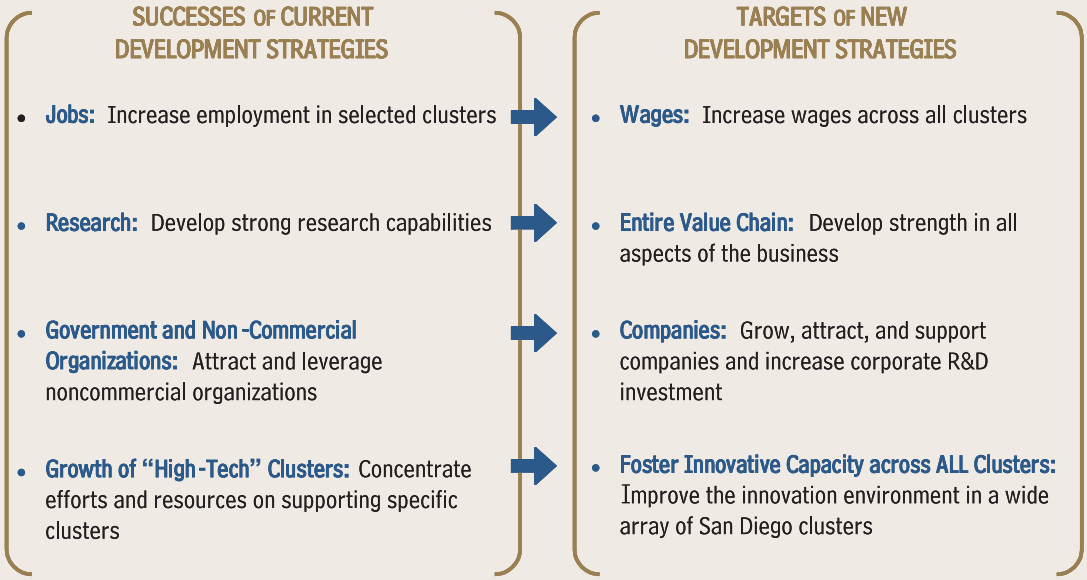
failed to cooperate they lost national competitions to host computer and superconductor research centers.

- **Anchor firms.** A few companies, notably Linkabit and Hybritech, spawned dozens of others. Other regions have recruited major firms to the area, and they too have produced many spin-outs. Large companies inevitably experience mergers, acquisitions, and reorganizations that result in lay-offs. When a region offers a high quality of life and an environment that supports start-ups, laid-off talent will begin their own companies rather than leave the area.

The Need for New Directions

San Diego has become a highly innovative and competitive region. Yet to remain competitive and complete the transition from a young and growing economy to a diversified, strongly performing one, several strategic changes must be accomplished:

- **From Jobs to Wages.** The region has been successful at creating many jobs. Wages, however, remain just at the national average, while the cost of living is above average. The task now is to raise wages.
- **From Basic Research to the Entire Value Chain.** San Diego leaders have successfully attracted many research institutions to the region. However, strength across the entire value chain needs to be developed. Clusters in the region need more sophisticated and demanding customers, more local suppliers who actively participate in improving goods and services, better specialized institutions providing training and support services, and more local firms vigorously competing with each other.
- **From Noncommercial Organizations to Companies.** The primary locus of innovation in San Diego has been in government and noncommercial research organizations such as SPAWAR, UCSD, Salk, and Scripps. As the San Diego economy matures, companies need to become more central to the innovation process with noncommercial organizations performing a vital, but supporting, role.



- **From "High-tech" Clusters to All Clusters.** "High-tech" clusters in San Diego such as biotech/pharma and communications are young and growing. They are not, however, the main employers in the region. The next step in San Diego's economic development is to encourage innovation and upgrading across all clusters.
- **From Regional Institutions to Cluster Institutions.** As the regional economy matures, there will be a need for strong cluster-specific collaborative institutions to foster supplier development, specialized training, international marketing, and the like, as well as an overarching institution which would facilitate cooperation among institutions for collaboration and help avoid redundant programs.

Challenges

- While San Diego has enjoyed much success, it also faces challenges.
  - **Cost of Living.** San Diego has a California cost of living with national average wages. This will make it more difficult for San Diego to compete successfully in the war for talent—one of the region's most important assets. San Diego's challenge is to boost innovation, which will increase productivity and enable employers to pay higher wages.
  - **Physical Infrastructure.** Rapid economic and population growth confront San Diego with a host of physical infrastructure issues. Failure to address them will likely result in a significant degradation of business efficiency, as well as the local quality of life, one of San Diego's key assets. Most critical will be increasing air transport capabilities, both passenger and cargo. San Diego, and California, must also generate reliable supplies of energy and water, greater sewage disposal capacity, and a better system of local roads.
  - **Quality of Life.** San Diego needs to develop a strategy to redefine and upgrade its quality of life. In the past, its climate, beaches, and small-town feel attracted scientists and researchers who were critical to the region's economic success. The climate will not change, but the beaches are more crowded and less accessible, and the city has grown into a sizeable metropolis. Put another way, the danger is that San Diego will look more and more like Los Angeles and Silicon Valley, but without comparable wages or cultural amenities.
  - **Human Resources.** Although San Diego's high-quality human resources have been a key source of success in the past, some skills will be lacking in the future. Some of the areas of deficit noted in interviews include digital processing and computer science, and management skills such marketing, promotion, sales, distribution, and human resource management. Continued upgrading of the K-12 education system was called for in our interviews throughout the region.
  - **Institutions for Collaboration.** Though formal and informal institutions for collaboration have been a strength in the past, the current capacity of institutions for collaboration will likely prove insufficient for the needs of the future. UCSD CONNECT is the only region-wide institution to receive high ratings in our survey, and informal networks will tend to become less effective as the economy grows, the number of people and firms that need to collaborate increases, and traffic congestion worsens.

- **Cluster Depth and Interaction.** Clusters in San Diego should build strength in all four determinants of innovative capacity: specialized inputs, related and supporting industries, context for firm strategy and rivalry, and demand conditions. In time, proximity to research will cease to be a source of differentiation. The presence of sophisticated local demand and numerous suppliers who all help firms innovate will likely become key advantages.
- **Internationalization.** Companies in San Diego need to compete more internationally. Although San Diego has high per capita exports and export growth rates, much of this is due to shipments of electronics parts to Mexico for final assembly and export back into the United States. Exports to the most competitive, most sophisticated markets in the world are an important benchmark of innovation success, and an important source of learning for further innovation.
- **Government Coordination.** Solving many of these challenges will require effective government action. While some governmental organizations, notably San Diego Regional Economic Development Corporation (SDREDC), received at least occasional accolades for their efforts, the general lack of government support, and the complexity of multilevel requirements for building and permitting (for example, the state-level California Conservation Commission versus local regulators) generally seem to have obviated the region's historically accommodating stance.

Opportunities

- In addition to confronting threats to historical assets, San Diego faces a number of major opportunities that are under-realized.
  - **Upgrading Traditional Clusters.** San Diego has the opportunity to support and boost innovation across a large number of clusters. Targeting just a few clusters for support will boost innovation, productivity, and wages in these clusters but risks creating a bifurcated economy where a relatively small number of people enjoy the prosperity of their innovations.
  - **Better Leveraging of the Military Presence.** In addition to the direct economic benefit and the potential for sourcing employees from the military, the Navy and the Department of Defense continue to offer strong core federal R&D funding. Opportunities exist to continue to develop commercial spin-offs from the development of military technology.
  - **Close Proximity of Mexico.** There are a number of opportunities to develop in areas like joint infrastructure improvement (e.g., air transportation, energy production, water supplies, sewage treatment), increased supplier and service provision for Mexico's maquiladora industries, increased trade with Mexico and Latin America in clusters like hospitality and tourism, education and knowledge creation, and health care.
  - **New Cluster Opportunities.** There appear to be a number of under-exploited, crosscutting cluster opportunities in the region. Examples might be: biotechnology and information technology, telecommunications and medicine, or biotechnology and agribusiness. There is a tendency for San Diego institutions to operate within "vertical silos" rather than to embrace "horizontal issues." Some of the failure to address these horizontal issues may stem from weaknesses in existing connecting institutions. The technology transfer process, for example, was described as very slow and cumbersome.

REGIONAL COMPETITIVENESS AND INNOVATIVE CAPACITY: CONCEPTUAL FRAMEWORK

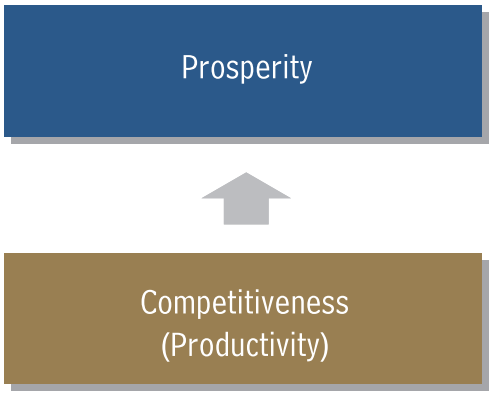
1

DETERMINANTS OF REGIONAL PROSPERITY

A nation's or region's standard of living is determined by the *productivity* of its economy. Productivity is the value of goods and services produced per unit of labor and capital. It sets the wages that can be sustained and the returns earned by holders of capital—the two principal components of a nation's or region's per capita income. Productivity sets prosperity at all geographic levels, whether it is a nation, a region (metropolitan area), or an inner city. In this report, our focus will be on the *regional* level.

Productivity, contrary to popular usage, is more than just efficiency. It also depends on the value of the products or services that a region's firms can produce as measured by the prices they can command. In advanced economies, productivity growth depends heavily on created higher value, products, services, and features, not just on improving the efficiency of processes.

Exhibit 1. Prosperity and Productivity



Competitiveness, then, is measured by productivity. The central challenge in enhancing the prosperity of a region is to create the conditions for sustained productivity growth.

Productivity does not depend on *what* industries a region competes in, but on *how* it competes. There are no industries that are inherently the most productive and thus more attractive in generating prosperity. In shoes, for example, Northern Italy supports high wages and profits because of the high value that consumers place on its products due to their design, materials, brand recognition, and distribution channels.

Regions should not attempt to pick "winners," or try to create new industries where there are no preexisting advantages to build upon. Instead, the challenge is to upgrade the sophistication and productivity of all the region's industries. Not all companies and industries will be equally successful, but success should be determined by the marketplace rather than intervention by government.

The most important sources of regional prosperity are created, not inherited. Inherited competitive advantages such as natural resources, location, or a supply of labor are becoming less important in determining prosperity, especially in advanced economies. Globalization has expanded the supply of natural resources, and technology has created new substitutes for them as well as bringing distant locations into the economy. A supply of labor is no longer an advantage in a world where low-skilled workers are plentiful. Prosperity depends not on inherited inputs themselves, but on creating the conditions that allow firms operating in the region to be highly productive in the use of inputs.

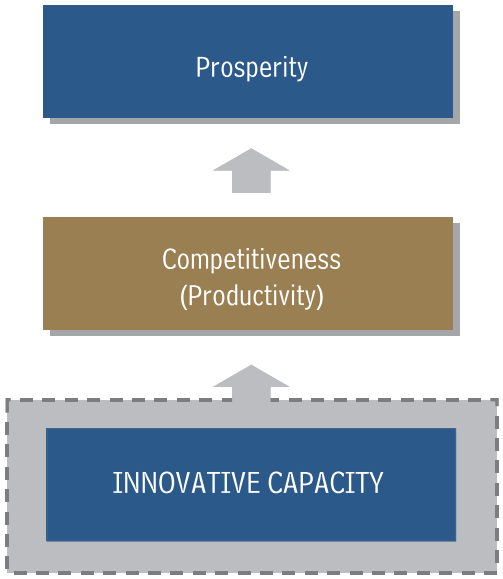
A good example is the oil and gas cluster in Houston. A modest quantity of oil and gas is still produced in Texas. However, Houston has become the world's center of technology and knowledge in oil and gas exploration and production, as well as the source of most of the sophisticated equipment and services required. This supports high wages and a large base of thriving companies. The most prosperous regions do not export natural resources or only physical products, but intellectual capital in various forms.

The prosperity of a region depends on the productivity of all its industries. The productivity of a regional economy depends on the average productivity of all its companies and industries, not just those that sell outside the region. For example, research on Japan[1] has shown that poor productivity of local industries such as transportation, construction, and wholesaling raised the cost of doing business and the cost of living, and thus became a drag on the prosperity of the country despite the existence of some very productive exporting industries. Regional competitiveness, then, depends on competitive local companies in fields such as utilities, transportation, and other local services.

Innovation and the Growth of Productivity

Maintaining, much less increasing, a region's standard of living requires the steady growth of productivity. No region in an advanced economy can maintain high wages, and hold its own in global markets, by producing standard products using standard methods. Lower-wage countries and regions are improving their skills and can rapidly access modern technology. In advanced regions, prosperity rests heavily on the *capacity for continuous innovation*.

Exhibit 2. Innovation and the Standard of Living



Innovation is more than just scientific discovery. Innovation stretches beyond science and technology, and includes all the activities involving the discerning of needs and the transformation of knowledge into commercial products, processes, and services. Indeed, some of the most important innovations today occur in sales, services and distribution; just think of the revolution in the small-package delivery that occurred in the last 15 years and resulted in U.S. global preeminence in this industry.

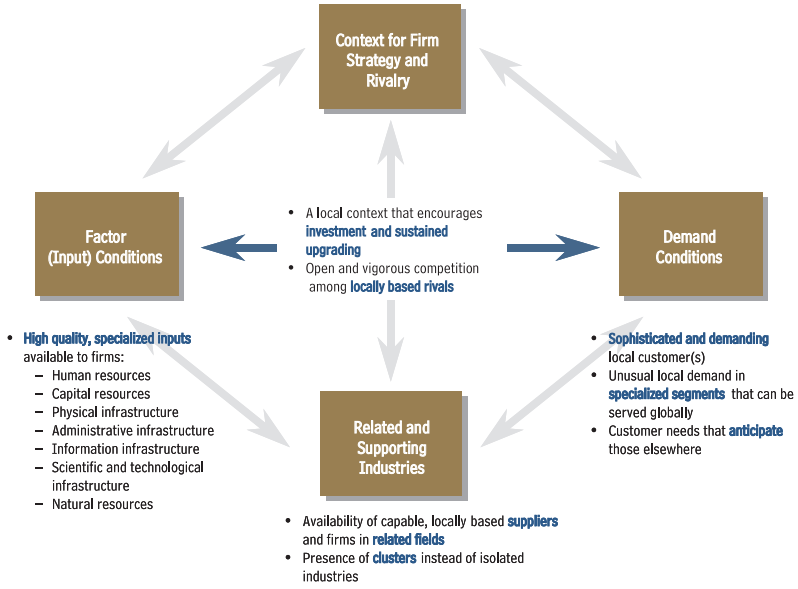
[1] See Michael E. Porter, Hirotaka Takeuchi, Mariko Sakakibara, *Can Japan Compete*, New York: Perseus Books (2000).

There are no low-tech industries, only low-tech firms. Today, innovation can drive productivity improvement in virtually every industry. Although industries producing enabling technologies such as computers, software, and communications have received much attention, opportunities to apply advanced technology are present in fields as disparate as textiles, machinery, and financial services. Hence, there are no "low-tech" industries, only low-tech companies that fail to incorporate new ideas and methods in their products and services.

THE MICROECONOMIC FOUNDATIONS OF PRODUCTIVITY

The productivity and innovativeness of a regional economy benefit from overall conditions such as a sound fiscal policy, a stable government, and sound legal institutions. However, broad regional attributes such as these are increasingly preconditions, not sources of competitive advantage.

Exhibit 3. Determinants of Regional Productivity



Prosperity in a region is actually created by the microeconomic foundations of competitiveness, rooted in the sophistication with which the individuals, firms, and industries based there compete. This includes the local subsidiaries of firms headquartered in other locations. At its core, competitiveness rests on the sophistication of company strategies and operating practices. However, the sophistication with which firms compete rests heavily on the quality of the regional business environment in which they operate. The productivity of companies is affected by such things, for example, as the quality of employees they can attract, the efficiency of the local logistics and transportation, and the costs of dealing with local regulations.

The quality of a region's business environment is embodied in four broad attributes that affect both current productivity and innovative capacity. [2]

[2] See Michael E. Porter, *The Competitive Advantage of Nations*, New York: The Free Press (1990).

Factor conditions: Achieving high levels of productivity depends on the presence of high quality and specialized pools of human resources, technology, infrastructure, and even sources of capital that are tailored to the needs of particular industries.

Demand conditions: The quality of demand at home has a strong influence on the process of creating and improving high-quality and distinctive products and services. Sophisticated customers in the region press firms to improve and offer insights into existing and future customer needs.

Context for firm strategy and rivalry: The rules, incentives, and pressures that govern the type and intensity of local rivalry have a fundamental influence on productivity and productivity growth. Policies that encourage investment and protect intellectual property foster productivity growth, for example. One of the strongest influences on productivity is the presence of competing local rivals.

Related and supporting industries: Local sourcing from capable suppliers based in the region can enhance productivity and improve the capacity for innovation through allowing quicker and less costly communication, fostering the flow of ideas, and enhancing flexibility. The presence in a region of related industries also boosts competitiveness through encouraging technological interchange and other complementarities.

These four attributes of a region's business environment are self-reinforcing and act as a system. Intense local rivalry, for example, stimulates the development of unique pools of specialized skills. It also encourages the formation or attraction of specialized suppliers, while upgrading regional demand by educating local customers.

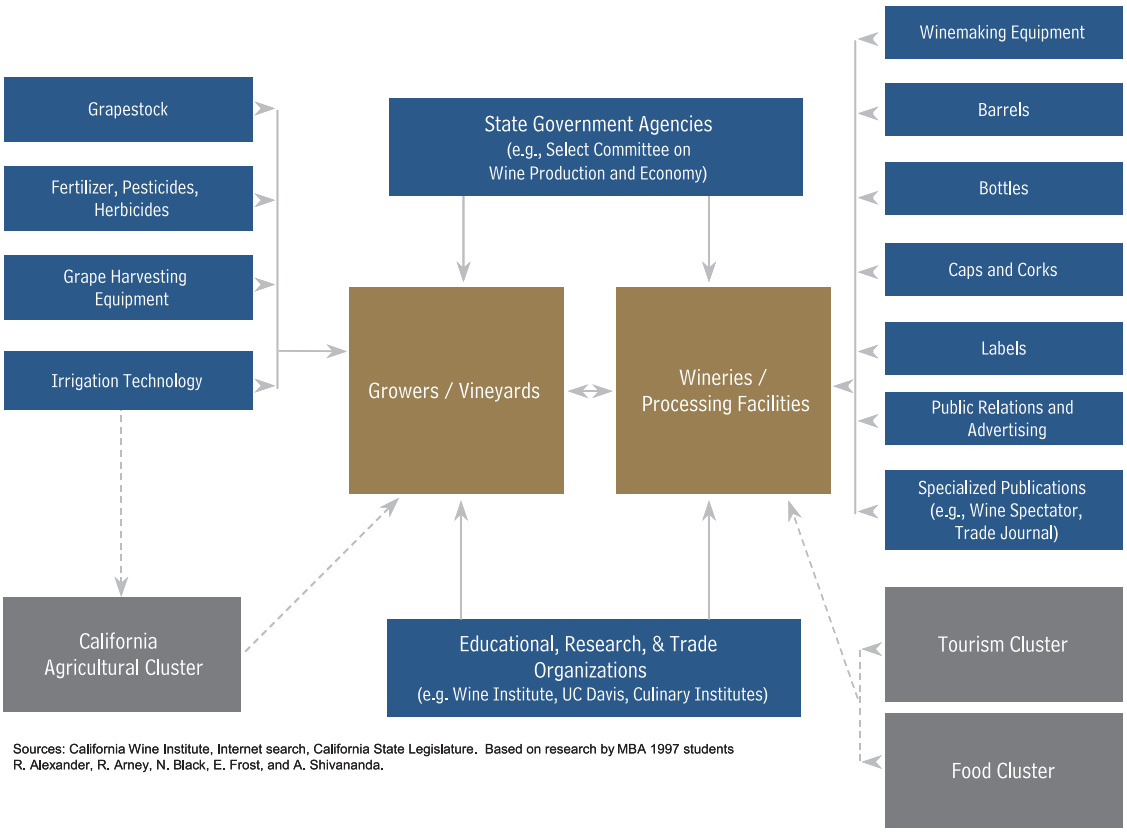
Attitudes toward business in a region — which are often termed "culture"— lie behind the diamond. They shape the behavior and aspirations of individuals, firms, and other local institutions. Of particular importance is an advanced economy like the U.S. are the beliefs about the bases for competitiveness, the importance of entrepreneurs, attitudes towards collaboration, and civic mindedness.

Clusters and Productivity

Clusters are geographically proximate groups of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities. Clusters are normally contained within a geographic area where ease of communication and interaction is possible. Sometimes they are concentrated in a single town. Specialization of regional economies in a range of clusters represents a striking characteristic of every advanced economy.

Clusters cut across traditional industry classifications. Clusters take various forms depending on their sophistication, the field of activity, location, and historical roots. Well developed clusters, however, normally include end-product or service companies; suppliers of specialized inputs, components, machinery, and services; financial institutions with expertise in the cluster; and firms in related industries. Clusters also often include firms in downstream industries; producers of complementary products; specialized infrastructure providers; government and other institutions providing specialized training, education, information, research, and technical support; and standard setting agencies. Finally, many clusters include trade associations and other collective private sector bodies that support cluster members (see Exhibit 4: The California Wine Cluster).

Exhibit 4. The California Wine Cluster



Sources: California Wine Institute, Internet search, California State Legislature. Based on research by MBA 1997 students R. Alexander, R. Arney, N. Black, E. Frost, and A. Shivananda.

Clusters enhance competitiveness in three ways.[3] First, they improve productivity because firms have ready, efficient access to specialized suppliers, skills, information, training, and technology in a demanding competitive environment. Extensive market, technical, and other specialized information accumulates within a regional cluster. Specialized inputs can be assembled, and relationships are forged among cluster participants. In a cluster, companies can hire specialized talent rather than have to train employees internally.

Second, clusters foster innovation by highlighting new needs and new processes, while giving companies the assistance and flexibility to try new things. Firms can work jointly with a local supplier to restructure the production process or introduce a new product.

Finally, clusters foster the creation of new firms through startups and spin-offs and by attracting subsidiaries of firms based elsewhere. This reinforces cluster productivity and innovation. Establishing a business in a cluster is easier than elsewhere, because all the inputs are readily available.

[3] See Michael E. Porter, *The Competitive Advantage of Nations*, New York: The Free Press (1990).

Clusters draw on both general and cluster-specific aspects of the business environment. Clusters benefit from national circumstances such as intellectual property laws, tax policy, and the general education system. The uniqueness of clusters, however, usually owes much to cluster-specific circumstances in a region.

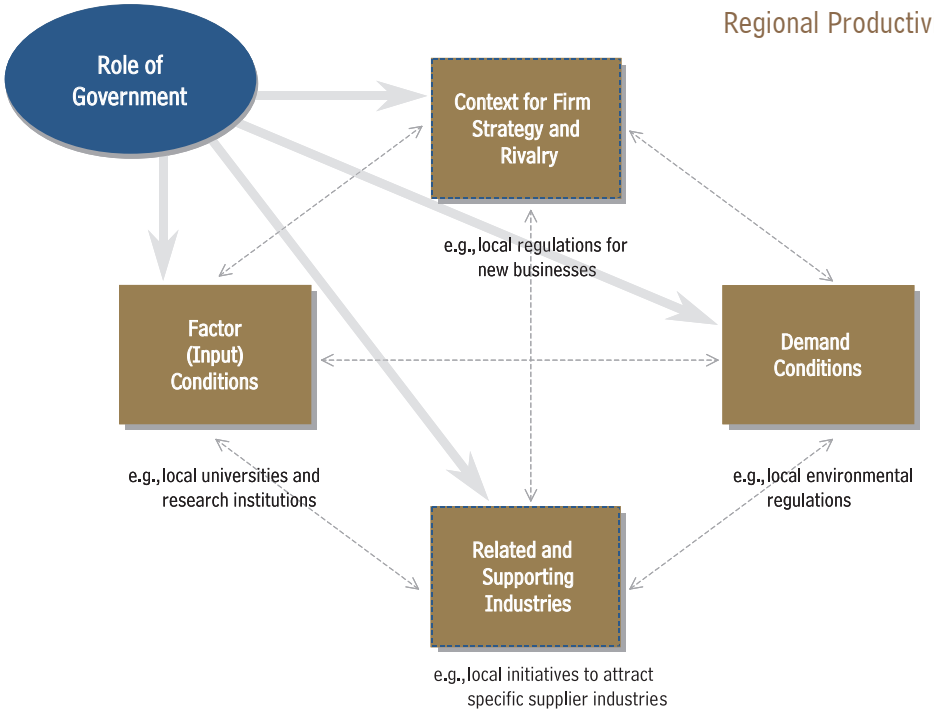
Local outsourcing from capable suppliers over vertical integration or outsourcing from distant suppliers. The presence of a full range of knowledge, inputs, machinery, and services makes experimentation easier and promotes greater efficiency and flexibility than vertical integration or relationships with distant suppliers.

The Role of Government

Some elements of a region's business environment arise spontaneously, or through the actions of individual firms and organizations such as universities and infrastructure providers. Many parts of the business environment, however, are influenced by government.

Government at all levels affects (positively or negatively) competition and innovation through policies and services that influence all parts of the diamond (see Exhibit 5). While the federal government is often seen as having the most impact on competitiveness, policies at the regional and even local level are often equally if not more important.

Exhibit 5. Government's Impact on the Determinants of Regional Productivity



Government's proper role is to improve the business environment rather than to intervene directly in the competitive process. Government should not subsidize individual companies but work to raise the productivity and innovativeness with which any company can operate. Many U.S. regions, for example, have traditionally sought to attract industry through tax incentives and lowering the cost of doing business in terms of payroll taxes, unemployment insurance, utility rates, and the like. This approach may be necessary in uncompetitive regions, but it is ultimately self-limiting. Reducing such costs can reduce the revenue necessary to improve a region's education, infrastructure, and services. Improving the productivity of the region, and boosting its innovative capacity, are the only ways to increase standard of living in the long run.

Government should foster the upgrading of all a region's clusters, not choose among them. All clusters offer opportunities to improve productivity and support rising wages, even those that do not compete with other locations. Every cluster not only contributes directly to national productivity but can affect the productivity of *other* clusters as well. This means that traditional clusters, such as agriculture, should not be abandoned but upgraded.

Government should reinforce and build on established and emerging clusters, rather than attempt to create entirely new ones. New industries and new clusters emerge best from established ones. Businesses involving advanced technology do not succeed in a vacuum, but where there is already a base of less sophisticated activities in the field. Most clusters form independently of government action — and sometimes in spite of it. Clusters form where a foundations of locational advantages exists to build on. To justify cluster development efforts, some seeds of a cluster should have already passed a market test.

Cluster upgrading involves removing obstacles, relaxing constraints, and eliminating inefficiencies that impede cluster productivity and innovation. Constraints include those of human resources, infrastructure, and regulation. Some can be addressed to varying degrees by private initiatives, but others result from government policies and institutions and must be addressed by government.

Exhibit 6. - Examples of Institutions for Collaboration

General	Cluster-specific
• Private sector - Chambers of Commerce - Professional associations • Public sector - Economic development agencies • Jointly private/public - Advisory councils - Competitiveness councils • Informal networks - School networks - Religious networks	- Industry associations - Specialized professional associations and societies - Alumni groups of core cluster companies - Incubators

Institutions for Collaboration

Institutions for collaboration are formal and informal organizations and networks that (1) facilitate the exchange of information and technology; and (2) foster various types of coordination and joint action that can improve the overall business environment or the workings of a cluster. They can cut across the economy or be cluster specific. Institutions for collaboration, then, create and amplify the arrows and feedback loops in the diamond. The quality of these institutions has a significant influence on competitiveness. Some examples of institutions for collaboration are given in Exhibit 6.

Institutions for collaboration enhance productivity and innovation in a number of ways. First, they create relationships and enhance the level of trust in these relationships. Second, they encourage the definition of common standards and rules. Third, they facilitate the organization of collective activity. Finally, they can be mechanisms to develop a common economic or cluster agenda.

The private sector has an important role in improving the local business environment, not just government. Companies can shape the business environment both through individual actions and joint initiatives. Private sector roles in cluster upgrading can be found in all parts of the diamond. Improving factor conditions provides the most obvious example, with efforts possible in enhancing the supply of appropriately trained personnel, the quality and appropriateness of local university research activities, the creation of specialized physical infrastructure, and the supply of cluster-specific information. The need for cluster participants to inform and prod government to address the constraints or weaknesses under its control cuts across all parts of the diamond.

Individual companies can independently influence cluster development, but collective efforts are often valuable, as trade associations and other institutions representing all or most cluster participants can command greater attention, achieve greater influence, and share cost versus individual members. Joint initiatives with other companies and the public sector leverage the impact of individual companies by pooling resources, coordinating complementary activities, and facilitating the exchange of knowledge and ideas.

REGIONAL INNOVATIVE CAPACITY

While all parts of the diamond affect a region's competitiveness, a subset of the business environment has particular importance in determining a region's innovative capacity (see the Council report *The New Challenge to America's Prosperity: Findings from the Innovation Index*[4]).

Some aspects of the business environment contribute to innovation across all or many fields. We refer to these as *common innovation infrastructure*. They include the university system, intellectual property laws, the pool of scientists and engineers, and the region's venture capital firms. While some common innovation infrastructure is determined nationally, most is regional in scope.

Other parts of the diamond that contribute to innovation are specific to particular regional clusters. They include the presence of specialized research institutions, individuals with particular technical skills, or venture capitalists who specialize in a particular cluster.

Institutions for collaboration have an important role in innovative capacity, just as they do in competitiveness overall. Especially important are the organizations and networks that facilitate technology transfer and bridge universities and firms.

Traditionally, firms and universities could operate separately. Firms had their own R&D departments, including basic research. Universities concentrated on academic research largely independent of the

[4] Michael E. Porter, Scott Stern, Council on Competitiveness, *The New Challenge to America's Prosperity: Findings from the Innovation Index*, Washington, D.C.: 1999.

private sector. Today, however, innovation depends on much greater company-university interchange. Companies depend not only on internal R&D but also technology from suppliers, specialized research institutions, and applied university research programs. In this new context, the need for institutions of collaboration has increased substantially.

THE COMPOSITION OF REGIONAL ECONOMIES

Regional economies are composed of several types of activities. The first is clusters that produce products and services that compete nationally and internationally. These clusters, which we term traded clusters, can be located anywhere. They consist of locally based firms and subsidiaries of firms based elsewhere that have research, manufacturing, and other sophisticated activities in the region and hence become part of that region's cluster as well.

A second type of activity in a region consists of firms that produce goods and services tied to the local market. These *local clusters* can be found in every region. They include such fields as retailing, utilities, and local construction services. Some regions have a third type of activity which we term resource-driven industries. These consist of firms that produce goods highly dependent on natural resources that are abundant in the region.

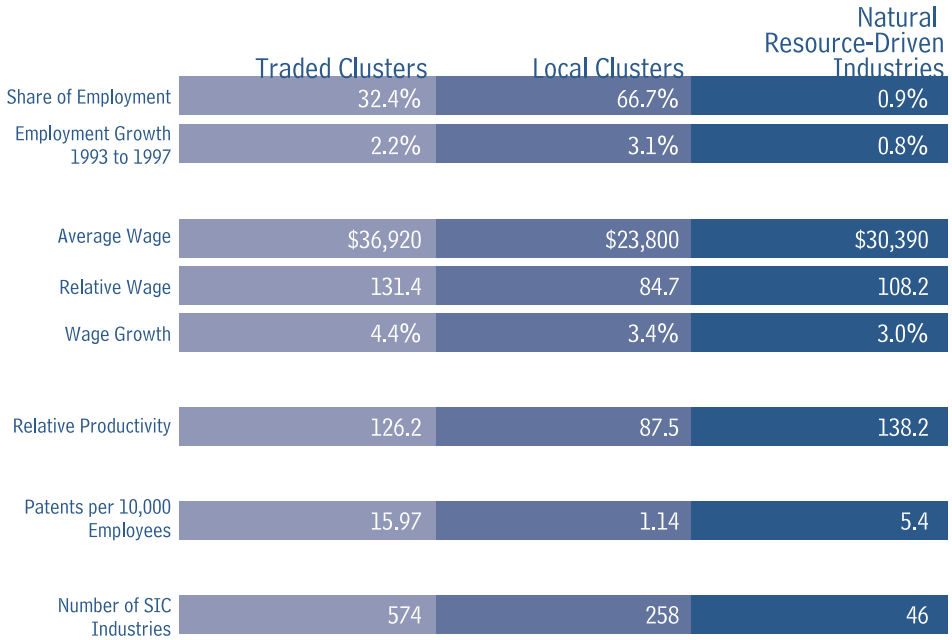
Finally, regional economies also include the *local operations of clusters based elsewhere*. These involve activities such as local sales, marketing, distribution, and service. Silicon Valley computer companies, for example, have numerous sales offices, service centers, and distribution facilities located in other regions. These "branch" activities, which are classified as part of traded clusters, are difficult to distinguish statistically from activities headquartered in the region. This means that most regions will have some employment in most traded clusters even though they are not competitive in many of them.

Traded clusters drive regional prosperity. While local clusters account for roughly two-thirds of employment in an average region, the prosperity and growth of a region are heavily driven by traded clusters. This is because traded clusters can achieve higher productivity, their growth is unconstrained by the size of the local markets, and their success creates much of the demand for local clusters.

Exhibit 7 shows the average composition of regional economics in the United States. Traded clusters accounted for 32.3% of total employment in 1997 and an estimated 32.4% in 1998, with an average wage in 1998 of $39,125. Local clusters account for 66.7% of employment in 1998 with an average wage of $25,053. The average wages of traded clusters have grown at a compound annual growth rate of 4.23% between 1988 and 1998, compared to 3.66% for local clusters.

The higher wages of traded clusters reflect their much higher productivity, shown in Exhibit 7. This, in turn, is due in part to the far higher rate of innovation in traded clusters as measured by patents per 10,000 employees.

Exhibit 7. Composition of Regional Economies in the United States, 1997



Note: *1977 data
Source: Cluster Mapping Project, Harvard Business School

Regional economies are highly specialized. The particular mix and evolution of traded clusters varies markedly from region to region, even in regions that are adjacent to each other. The mix of clusters, and their competitive strength versus other regions, has much to do with the average wage in a region and employment growth. There is a strong association between traded wages in a region and the wages local industries can command.

A detailed analysis of the clusters in each region, their relative wages, their innovative output, their particular mix of industries, and their evolution over time is an important component of the analysis of each region.

REGIONAL STUDY METHODOLOGY 2

The Clusters of Innovation Project examines five regions: San Diego, Atlanta, Pittsburgh, Raleigh-Durham, and Wichita. For the purposes of this study, a region is defined as a metropolitan statistical area (MSA) using U.S. Department of Commerce boundaries.[5] The five regions were selected to provide a diversity of size, geography, economic maturity, and perceived economic success. The regions are similar enough to allow interesting comparisons, yet diverse enough to encompass a wide variety of challenges and opportunities in regional economic development.

The focus of the regional analysis is on both overall competitiveness and capacity for innovation, a key enabler of future competitiveness. In each region, we examine five areas:

- Regional economic performance
- The composition and evolution of the regional economy
- Assessment of the region's business and innovation environment
- The competitiveness of selected regional clusters
- Implications for the regional agenda

Data for the study were drawn from a number of sources. Performance indicators were assembled from a variety of sources such as the County Business Patterns, Department of Commerce Trade Statistics, PricewaterhouseCoopers Money Tree, and the Inc. 500 List.

The principal source of quantitative data on the composition and performance of the overall economic picture and specific clusters was the Cluster Mapping Project of the Institute for Strategy and Competitiveness at Harvard Business School. The Cluster Mapping Project has compiled in-depth data on employment, wages, establishments, and patenting activity by cluster at the country level. It provides an objective basis to compare the composition of regional economies and assess the relative position of a region's clusters (see the description below).

To analyze the business and innovation environment, we reviewed previous studies and conducted primary research. To generate new quantitative data, an extensive Clusters of Innovation Initiative Regional Survey was conducted of business, government, and non-profit leaders in the region (the full Clusters of Innovation Initiative Regional Survey is available on the Council on Competitiveness website at www.compete.org). Surveys were completed by 232 executives at companies and institutions throughout the region. Of the total, 103 were companies from the biotech/pharmaceutical and communications cluster, and 65 were from regional institutions of collaboration and other non-cluster organizations (e.g., venture capital firms, banks), and another 64 were from companies in a range of clusters.

[5] In the case of Atlanta, the region is defined as the Atlanta MSA, plus three additional counties: Troup, Harris, and Muscogee, included to better capture the economic linkages in the Atlanta area.

We also conducted in-depth interviews with a selection of San Diego leaders. Of these, 23 were with business executives in the biotech/pharmaceutical and communications cluster, 4 were with executives in other clusters, and 22 were with representative from academic, government, or collaborative institutions.

Regional Economic Performance

The study examined regional economic performance on two levels. At the broadest level, we compared the region to other regions on various indicators of economic vitality and standard of living such as employment, wages, productivity, and exports. To assess potential future competitiveness, we examined measures of innovative output and entrepreneurship including patents, venture capital investments, the prevalence of fast growing companies, and initial public offerings. Wherever possible, we tracked both the level and the growth rate of each performance indicator (see Exhibit 8).

We compared the performance of the San Diego regional economy to the national economy as a whole, as well as to other technologically intensive regions.

Exhibit 8. Economic Performance Indicators

Overall Economy	Innovation
• **Employment** *Number of persons employed*	• **Patents** *Number of patents and cited patents*
• **Wages** *Payroll per employee*	• **Venture Capital Investments** *Value of venture capital investment*
• **Productivity** *Value of shipment per person employed*	• **Fast Growth Firms** *Number of companies on Inc. 500 list and Gazelle-type companies*
• **Exports** *Value of manufacturing exports*	• **Initial Public Offerings** *Number of Initial Public Offerings*

The Composition and Evolution of the Regional Economy

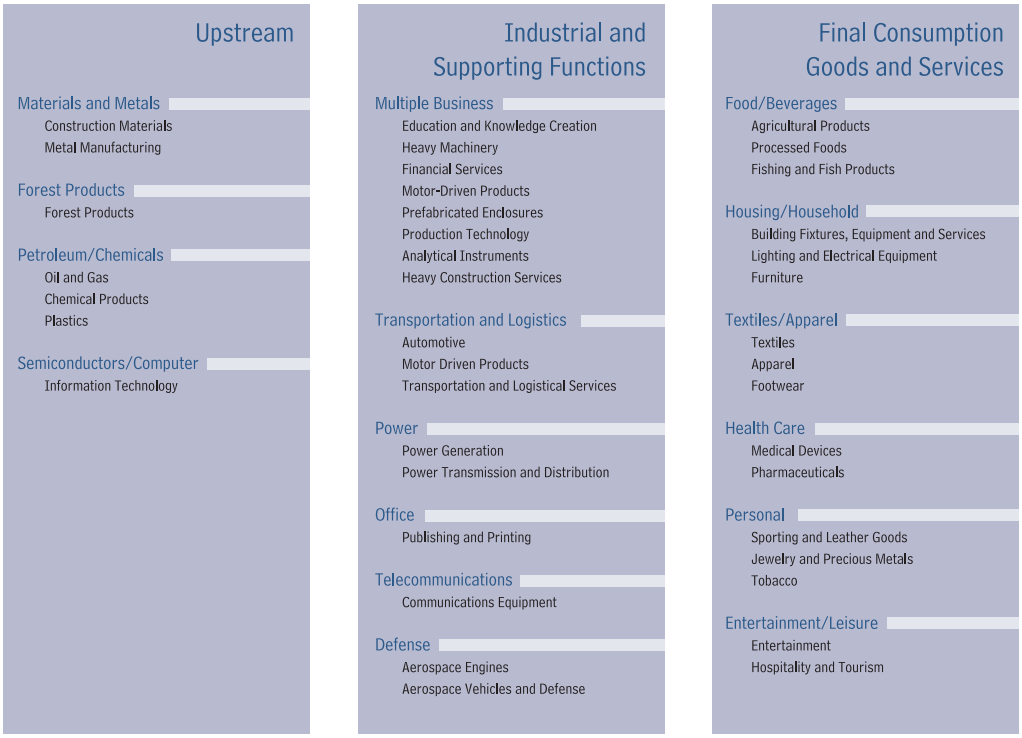
Especially in advanced nations such as the United States, regional economies are specialized, with each region strong in a different mix of industry clusters. Comparing regional economies has been difficult because clusters have not been systematically identified or mapped across all U.S. regions. To address this challenge, Professor Porter and his team at Harvard Business School have defined clusters statistically and assembled detailed data by industry and cluster on employment, wages, establishments, and patenting over time for every region in the United States. (See the boxed insert for a summary of the Cluster Mapping Project).[6]

The cluster mapping data is used to identify the most important clusters in the region's economy, understand the drivers of the region's relative wages, employment growth, and formation of new establishments, assess the region's patenting performance, and examine the region's relative position versus other regions overall as well as in its leading clusters.

[6] By traded, we mean that the location of the firms in these clusters is not driven by the need to be near a specific natural resource, or by population concentration. Instead, these industries are located in a specific area for some reason related to the region's innovative capacity.

CLUSTER MAPPING PROJECT METHODOLOGY

- The purpose of the Cluster Mapping Project is to assemble a detailed picture of the location and performance of industries over in the United States, with a special focus on the linkages or externalities across industries that give rise to clusters.
- The raw data for the project are County Business Patterns data on employment, establishments, and wages by four-digit Standard Industrial Classification (SIC) Code by U.S. county. In addition, U.S. patent data by location of inventor are allocated to industries and clusters using a concordance of technology, classification with SIC Code
  - Confidentiality limitations mean that actual data are not disclosed for every county and economic area in every industry. Various techniques are used to compensate for missing data.
- Economies are analyzed at various geographic levels, including states, economic areas, metropolitan statistical areas (MSAs), and counties.
- All the industries in the economy are separated into "traded" and "local" based on the degree of industry locational dispersion across geographic areas. Local industries are those present in most if not all geographic areas, and primarily sell locally. Traded industries are those that are concentrated in a subset of geographic areas, and sell to other regions and nations.



- For traded industries, clusters are identified using the correlation of industry employment across geographic areas. The principle is that industries that are normally located together are those that are linked by external economies, and constitute a cluster.
- Clusters are defined initially using state-level data (n=50). The robustness of clusters is defined using the state as the economic area and tested using smaller geographic units.

CLUSTER MAPPING PROJECT METHODOLOGY (CONT.)

- Clusters are constructed using two approaches, which are reconciled:
  - Select a "core" industry in a field or activity. Calculate locational correlations of all other industries with the core. Those industries with statistically significant correlations with the core define the extent of the cluster.
  - Calculate locational correlations between all pairs of industries in a field and related fields. Those industries with statistically significant and substantial intercorrelations defines the cluster.
- In both cases, industries with "spurious" correlations to the cluster are eliminated using Input-Output tables, industry definitions, and industry knowledge.[7]
- Cluster industries are separated into "Tier 1" and "Tier 2." Tier 1 industries are those industries that are most correlated with a given cluster, while Tier 2 industries are significantly correlated with that cluster but more correlated with another cluster.
- Analysis using Tier 1 industries eliminates cluster overlaps. An industry is a Tier 1 industry for only one cluster.
- Analysis using both Tier 1 and Tier 2 industries includes the overlap among clusters. This overlap is important to understanding cluster competitiveness, but leads to double counting of employment.
- Subclusters, or subsets of industries in a cluster that are particularly correlated with each other, have been defined for each cluster. Subclusters are separately defined for Tier 1 and Tier 2 industries. There are 244 subclusters of Tier 1 industries and 245 subclusters of Tier 2 industries within the 40 traded clusters.

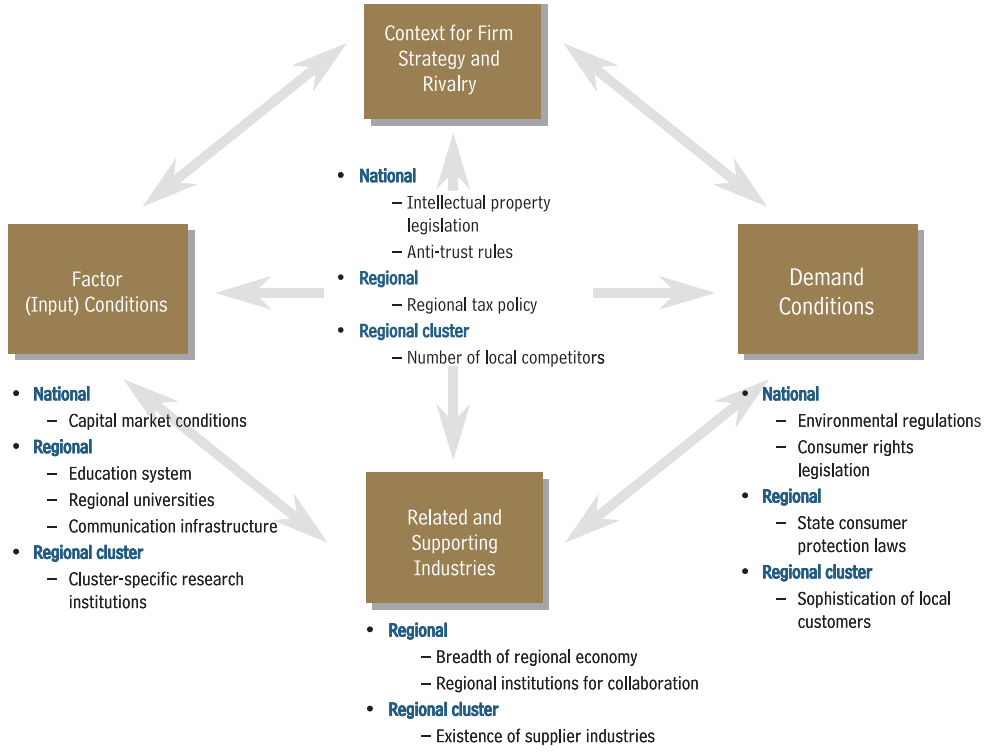
Assessment of the Region's Business and Innovation Environment

The quality of the overall business and innovation environment includes both common characteristics that affect the entire economy, and the particular circumstances in important regional clusters. We examine overall competitiveness but place special emphasis on the region's innovation environment. The competitiveness of a region is affected by circumstances at three levels: national, regional, and cluster specific.

Exhibit 9 gives examples of the types of influences that must be assessed in the regional analysis that follows.

[7]The 1992 Input-Output Accounts measure the share of economic value traded between industries.

Exhibit 9. National, Regional and Cluster Level Circumstances



The exhibit below illustrates some of the specific dimensions of the overall business environment analyzed in the research.

Exhibit 10. Business Environment and Cluster Indicators

	Common	Cluster-Specific
Basic and Specialized Factor Inputs	☐ Information and communication infrastructure ☐ Skilled workforce ☐ Investment in educational capacity ☐ Availability of risk capital ☐ Quality of life	☐ Presence of specialized research centers ☐ Presence of specialized talent base ☐ Presence of specialized training and education institutions
Context for Firm Strategy and Rivalry	☐ Tax policy (e.g., investment incentives)	☐ Intensity of rivalry among firms in the cluster ☐ Degree of cooperation between firms in the cluster
Related and Supporting Industries	☐ Regional position in broad based industries such as business services and energy	☐ Extent of related industries inside and outside of the cluster
Sophistication of Demand	☐ Overall regional education and per capita income levels	☐ Sophistication of the demand in the region for the clusters' products and services
Government	☐ Zoning regulations ☐ Coordination between government agencies	☐ Cluster-specific regional policies
Institutions of Collaboration	☐ Existence of regional institutions of collaboration	☐ Existence of cluster-specific institutions of collaboration
Attitudes toward Business	☐ Regional attitudes toward the sources of economic prosperity	☐ Cluster-specific attitudes toward the sources of economic prosperity

The Competitiveness of Selected Regional Clusters

In each region, two or more clusters were selected for in-depth analysis. While an analysis of all important clusters is necessary and desirable, the limitations of time and resources meant that we utilized studies of a few clusters to gain insight into the region's challenges and opportunities at the cluster level. See Exhibit 11 for a list of the clusters analyzed in each region.

Exhibit 11. Clusters Studied in Each Region

San Diego	Atlanta / Columbus	Pittsburgh	Wichita	Raleigh-Durham
• Pharmaceuticals / Biotechnology • Communications	• Financial Services • Information Technology • Transportation and Logistics	• Pharmaceuticals / Biotechnology • Information Technology • Production Technology (includes Robotics)	• Advanced Materials / Plastics • Aerospace Vehicles and Defense • Communications	• Pharmaceuticals / Biotechnology • Communications • Shorter case studies of Chemicals, Fibers and Plastics

Clusters were chosen based on size, importance to the region, stage of development, and perceived success. We also coordinated the choice of clusters across regions to permit cross-regional comparisons. Overall, eight of the 40 traded clusters were analyzed in at least one region. Using the overlaps, we were able to investigate differences across regions in the economic and innovation performance of the same cluster (e.g., biotech/pharmaceuticals in San Diego, Pittsburgh, and Raleigh-Durham).

To assess the performance of a cluster, we compared a particular regional cluster (e.g., biotech/pharmaceuticals in San Diego) to the national cluster and to other benchmark regions (e.g., the biotech/pharmaceutical cluster in Boston).

In analyzing each cluster, we paid particular attention to its historical evolution, not just its current circumstances and future challenges. The process by which clusters developed was both revealing and important to understanding how the region might expand its economic base into new fields.

Implications for the Regional Agenda

The study concludes with implications for private and public sector leaders at the regional and cluster level.

Implications are discussed in three stages: First, the study summarizes the main accomplishments of the region and the lessons to be drawn from its past history. Second, the research is used to highlight any needs for new economic directions for the regions where past strategies need to be modified to support the next stage of the region's development. Finally, the study outlines the specific challenges that must be overcome to move regional innovative capacity forward, as well as the new opportunities for the region to upgrade.

The study's objective is not to develop a specific action plan for regional leaders. However, the implications of this research for the regional agenda allow a regional competitiveness initiative to focus its work on the main levers to further improve the regional environment for prosperity and innovation.

3 ASSESSMENT OF THE SAN DIEGO REGIONAL ECONOMY

The current success of the San Diego economy, as with any economy, grows out of a decades-long process. It began with the development of a strong core of military and then bio-science research institutions. These institutions, which over the years have enjoyed considerable federal funding, are the taproots of the region's economic growth. San Diego has attracted, trained, and retained talented technical workers, in part because of a highly desirable quality of life. The area's business, academic, and government leaders have fostered attitudes toward business that value entrepreneurial risk-taking and collaboration between private firms and research centers. These assets helped the region emerge from the severe economic challenge posed by defense cutbacks at the beginning of the 1990s. Today, San Diego's economy is growing and contains a more diverse set of industries.

For all its progress, however, and in part because of this progress, San Diego faces significant challenges. Wages in San Diego, even in high-technology industries, are at or below comparable national averages. Rapid growth has given rise to a number of social and economic trends — such as a deteriorating quality of life and pressure on the primary and secondary school systems — that could undermine the region's historical advantages.

Our analysis focuses on the economy of San Diego County, which corresponds with the San Diego metropolitan statistical area (MSA), as defined by the U.S. Department of Commerce. We begin with a brief historical perspective, which is essential to understanding San Diego's past successes and current challenges. We then evaluate the economic and innovation performance of the region using a variety of metrics. To understand this performance, we describe the composition of the economy and its position vis-à-vis other regions. We then assess the strengths and weaknesses of the region's competitiveness and innovative capacity using diamond and cluster theory. The numerous issues and challenges uncovered in the analysis are expanded upon in the final chapter.

Historical Perspective on the San Diego Regional Economy

San Diego started with an attractive physical environment and some attractive natural assets: the proximity to ocean and a good harbor, the mesa, a pleasant climate and, perhaps not least, a certain isolation which allowed for a good quality of life. In its earliest days, the city attracted the primary agricultural and marine industries as well as tourism.

The economy that developed based on these industries was narrow and only modestly prosperous. The local government, understandably, proved very accommodating to those individuals and institutions which might improve the situation. Specifically, government accommodation generated two strands of economic

development that have since proven critical to the economic development of San Diego: a "military strand," which has yielded such clusters as telecommunications, transportation and logistics, aerospace vehicles and defense, analytical instruments, information technology, and power generation; and a "research institution strand," which, in turn, underpinned such clusters as biotechnology/pharmaceuticals, and medical devices.

Over time, these two strands became interwoven. Challenged by discontinuities, cluster-generating companies (e.g., Linkabit, Hybritech) and crusading individuals (e.g., William Otterson and Richard Atkinson) forged interrelationships, promoted the development of supportive institutions (e.g., the University of California at San Diego-UCSD), and pioneered the growth of the present clusters.

The Role of the Military. In 1908, President Theodore Roosevelt visited San Diego, was importuned by the city fathers to build a naval headquarters there. He promised a naval presence if the city dredged the bay. The city complied and the naval base opened. The U.S. Representative from San Diego continued to lobby for military installations and succeeded in bringing a Navy Training Center, Camp Pendleton (U.S. Marine Corps), and ultimately the Naval Air Station on North Island, which was attracted to the area by the near-ideal conditions for year-round flying. Once again, the city "accommodated" by making the land for the airfield available.

The home-porting of the Third Fleet in San Diego ultimately led to the development of the naval laboratory (now the Space and Naval Warfare Systems Command—SPAWAR), which opened more than 60 years ago. The laboratory, and the significant R&D budgets it entailed, created a research community focused on government, notably naval and Department of Defense, priorities. This research community attracted talented people, many of whom later became prominent in the development of San Diego's telecommunication cluster. For example, Irwin Jacobs and Don Viterbi, the founders of Linkabit and later, QUALCOMM, founded their first company as a result of consulting work done for the lab. Moreover, SPAWAR sponsored many early corporate projects directly. For example, a number of QUALCOMM projects were initially funded by the Defense Advanced Research Projects Agency (DARPA).

The combination of the Naval Air Station and the Naval Lab also attracted defense companies: first, the aircraft companies, notably Convair, later a division of General Dynamics, and subsequently a large number of aerospace and missile companies (e.g., Megatech, TRW, and Raytheon). Existing defense companies also spun out new divisions or entirely new firms. For example, General Dynamics created General Atomics, a division focused on developing peaceful uses for nuclear energy, which later became a privately owned company. Once again, the city made the land available for the new company; subsequently, Robert Beyster left General Atomics to found Science Applications Investment Corp (SAIC), now one of the nation's leading technology consulting organizations.

The growing presence of research-oriented defense companies promoted, often consciously and deliberately, the development of needed supporting and collaborative institutions. For example, Richard Atkinson, the current president of the University of California, stated that "one of the most important events" in the economic history of San Diego was the "campaign of SAIC and General Atomics to attract a UC campus" to the area. Defense and research companies also sponsored the extension of the univer-

sity, once established. For example, General Atomics "sold" the university on the International Thermonuclear Experimental Reactor (ITER) and "the university, in turn, sold the mayor and the governor." In another example, General Atomics catalyzed the creation of the Super Computer Center at UCSD.

The aerospace and defense industries, whose growth was stimulated by World War II and boosted by the subsequent Cold War, faced a discontinuity with the end of the Cold War and the subsequent downsizing of the military. The city initially reacted to the cutbacks by attempting to build government-business-university alliances and by bidding for both Sematech and MCC (two consortia of semiconductor and electronics manufacturers that foster collaboration on R&D). These bids failed. Ultimately, however, San Diego's version of the peace dividend arrived due to the defense engineers and managers diverted, by the loss of their jobs, into entrepreneurial pursuits. As William Stensrud of Enterprise Partners said, "General Dynamics, TRW, General Atomics and SAIC had recruited thousands of talented scientists and engineers … all of a sudden San Diego had a number of smart, hungry, bright experienced people looking for work." The net result of this migration was the creation of scores of companies, many of them in the telecommunications sector, importantly based on military technology, military contracts, and military contacts (i.e., informal networks).

The Role of Research Institutions. The growth of the extensive set of not-for-profit research institutions in San Diego presents a similar story, although one that is both smaller in scale and less marked by severe disruptions than the military development.

In the late 1950s and early 1960s, three major research institutions were established in San Diego. Leaders of the Scripps Metabolic Clinic, which had been in San Diego since 1924, decided to devote a large portion of their limited funds to the construction of new research facilities and the recruitment of talented and entrepreneurial researchers. The result was the the Scripps Research Institute (Scripps) which was founded in 1955[8]. At the same time, a visit by Jonas Salk sparked his interest in opening a research facility in San Diego. The City of San Diego seized the opportunity by zoning the Torrey Pines Mesa exclusively for research and donating land there to Salk. The Salk Institute opened in 1960. Finally, SAIC and General Atomics organized a campaign to bring a University of California to La Jolla[9]. As a result of these efforts, the city became a national center for R&D in bio-science and oceanography. The existence of one world-class research organization attracted others and honed the skills of those already in the area. Among the other institutions attracted were the Burnham Institute and the Sidney Kimmel Cancer Center.

Researchers at these institutions forged powerful informal networks, characterized by good communication of shared knowledge. They also spun out various corporate entities, based largely on the basic research they developed. The institutes also helped to attract and support the UCSD campus and other institutions as well as to identify and promote extensions to them. Over time the research institutions went beyond biotechnology and began to interrelate with other local industries (e.g., telecommunications).

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[8] www.scripps.edu.
[9] Interview with Richard Atkinson, December 9, 1999, San Diego.

The Clusters of Today. San Diego's contemporary economy has been heavily shaped by these two development strands. Almost every one of San Diego's large and growing clusters grew due to the presence of the military or bio-science research, or because of its geographical attributes, which encourage industries related to tourism and agriculture. The military spawned clusters such as transportation and logistics, communications, analytical devices, information technology, aerospace vehicles and defense, and sporting and leather goods. The research centers produced biotechnology/pharmaceuticals, medical devices, and education and knowledge creation. Had past leaders failed to foster these two strands of development, it is difficult to imagine San Diego rebounding so quickly from the defense cuts, and partaking so fully in the rapid growth experienced by the United States in the 1990s.

REGIONAL ECONOMIC PERFORMANCE

The San Diego economy does well in most measures of performance. It has high employment, good levels of productivity and exports, and strong patent registration. However, average wage levels throughout the region have not matched employment, export, and innovation performance. Wages in San Diego are slightly below national averages.

The recession and layoffs of the early 1990s were more severe in San Diego than in other parts of the country, but the subsequent employment growth has been greater. Growth in exports and especially innovation output have also been strong over the past decade. Wages seemed to be growing strongly over the past four years.

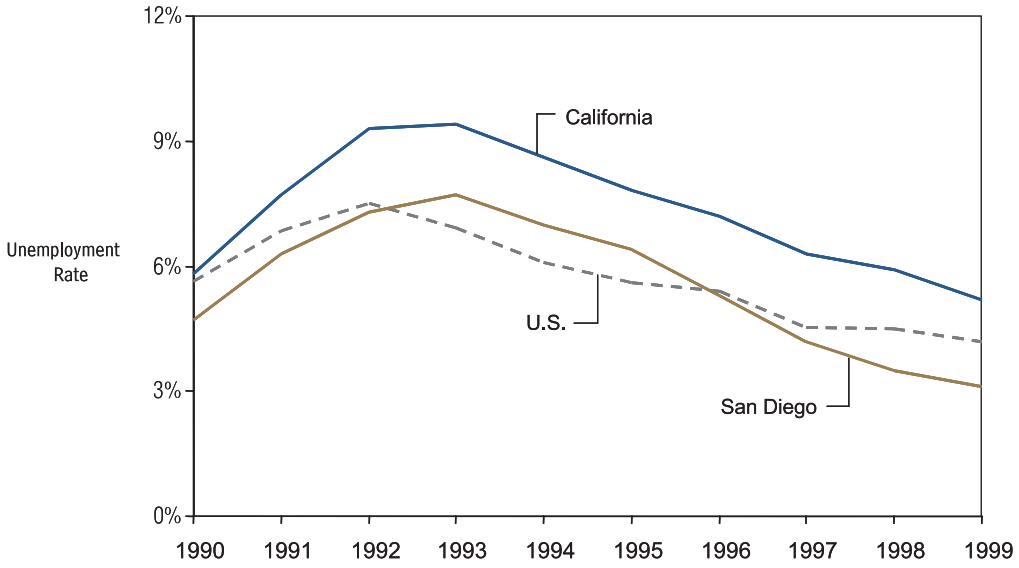
Indicators of Overall Economic Performance

To assess the overall economic performance of San Diego's regional economy, we compare it to the nation and several benchmark regions on the following metrics: employment, average wages, productivity, and exports.

Employment. The San Diego economy has performed well in terms of employment growth over the last decade. The number of civilian employees in 1999 was 1.36 million, up from 1.15 million in 1990.[10] From 1988 to 1997, the compound annual rate of growth of employment in San Diego was 1.9%, well above California's 1.1% growth, but just below the national rate of 2.0%. Employment growth increased after 1997, as is shown by unemployment data. The unemployment rate in San Diego reached a high of 7.7% in 1993, but then dropped to 3.1% in 1999, below both California's rate of 5.2% and the nation's rate of 4.2% (see Exhibit 12). Unemployment rates in 1999 for benchmark regions were 2.2% in Boston, and 3.0% for San Jose.

[10] This number includes government and farm labor that is not included in the CMP data.

Exhibit 12. Unemployment Rates in San Diego and the United States, 1999



Source: US Bureau of Labor Statistics, and the California Employment Development Department

Average Wages. The average wage in San Diego in 1997 was $28,855, slightly below the national average of $28,945. Wage growth from 1988 to 1997 was 3.6%, slightly faster than the national growth rate of 3.5%. These lower than average wages are not due to the large military presence in San Diego because our data exclude the military.

For traded industries, which tend to pay higher wages, the 1997 index of San Diego average wages to U.S. average wages was 102.6, or 2.6% above the national average; excluding the hospitality and tourism cluster, which pays relatively low wages, the index was 103.5.[11] Only three of San Diego's 10 largest clusters pay average wages higher than the national average for that cluster.[12] In high-technology industries, San Diego's average wage index in 1997 was 101.7.[13] The index for California was 111.6; for Boston it was 114.2; and for Austin — a city with a cost of living lower than San Diego's-it was 98.4.

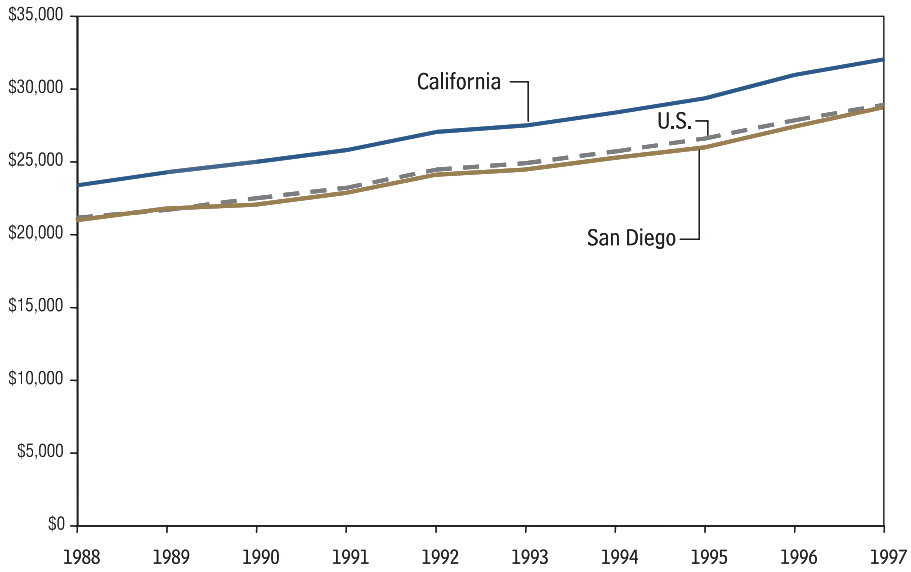
Growth in average wages has been slightly faster than for the nation and for many benchmark regions, albeit from a lower base. Wage growth for the region as a whole was roughly the same as for the nation from 1988-1997 (see Exhibit 13). Wage growth in San Diego's traded industries was faster, going from an index of 96.4 in 1988 to 102.6 in 1997. In high-tech industries, San Diego's average wage index went from 94.6 in 1988 to 101.7 in 1997. Comparison numbers for other regions are: 107 to 111.6 for California; 109.8 to 114.2 for Boston; and 91.1 to 98.4 for Austin.

[11] All of these indexes are employment weighted.

[12] The clusters are business services, education and knowledge creation, and construction services.

[13] San Diego Area Government's Association (SANDAG) identified 83 high-tech 4-digit SIC industries (see *Developing High-Technology Communities*: San Diego (Office of Advocacy, U.S. Small Business Administration, April 2000). We have 1997 average wage data for 50 of these.

Exhibit 13. Average Wages of Selected Regions, 1988-1997



Note: Average wages are nominal
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

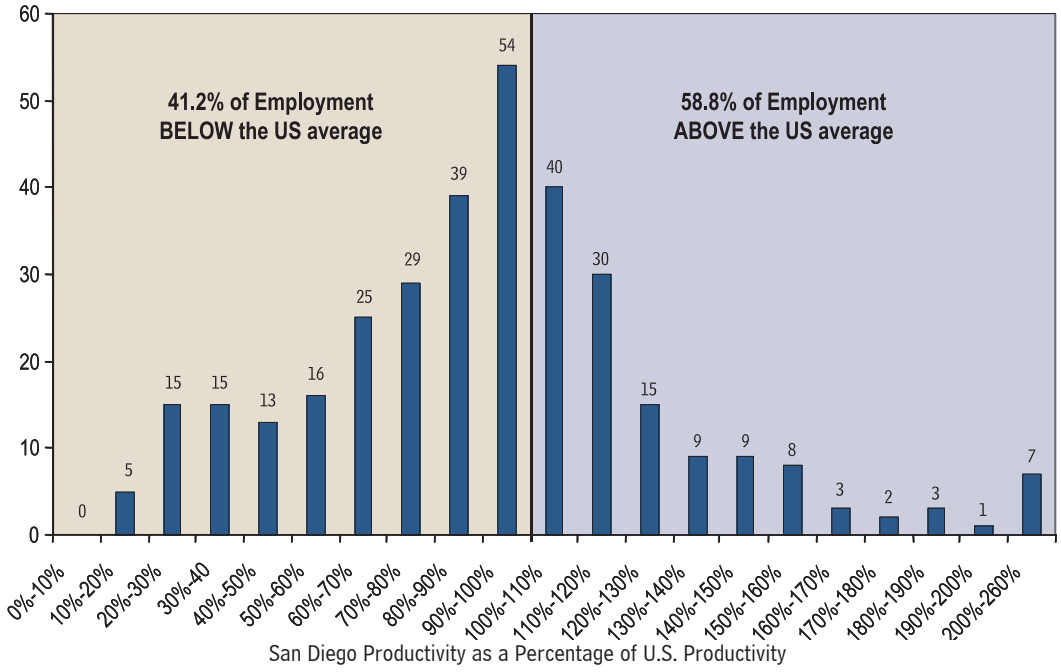
Cost of Living. According to Baker Thompson and Associates estimates, the cost of living in San Diego is approximately 23 percent higher than the average U.S. metro area.[14] In 1999, housing costs were an estimated 50% percent higher than the national average. In the past six years, the average sale price of a 2,200 sq. ft house in San Diego has risen from $250,000 to approximately $400,000. This increase echoes the national growth in home prices of about 6% a year; however, the average price of a home in the U.S. is only $164,000, less than half of the San Diego average price. The housing prices in the main technology areas are higher and rising even faster than the San Diego average.

Productivity. Our measure of productivity compares output per employee of an industry in a region to the output per employee of that same industry nationwide.[15] An index of 100 means that a region's productivity in an industry equals the nation's average for that industry. Any region will have a mix of some industries that are more productive than average and others that are less productive. Exhibit 14 below shows San Diego's mix.

The productivity of San Diego's overall economy exceeds U.S. productivity. Its weighted average index is 103.6, or 3.6% greater than the nation's productivity. Fifty-eight percent of the employees in our sample worked in industries that were more productive than the national average for their industry. The productivity of San Diego's high-technology industries is also better than the national average, as well as of many benchmark regions.[16] San Diego's weighted average productivity index is 108. The comparable numbers for benchmark regions are 107 for California, 113 for Boston, and 94 for Austin.[17]

[14]This paragraph relies on data from the Baker Thompson and Associates, Economic Reference Report.
[15]For a detailed explanation of this productivity measure see Appendix 3.
[16]See SANDAG's definition in Developing of High-Technology Communities: San Diego (Office of Advocacy, U.S. Small Business Administration, April 2000). One industry-help supply services (7363)-significantly skews the data upwards. Excluding 7363, the employment weighted average index of these industries is 112.5 (156.5 including 7363).
[17]These numbers all exclude SIC 7363, help supply services (temp agencies), which skew the index up dramatically in each region.

Exhibit 14. San Diego Regional Productivity, 1997

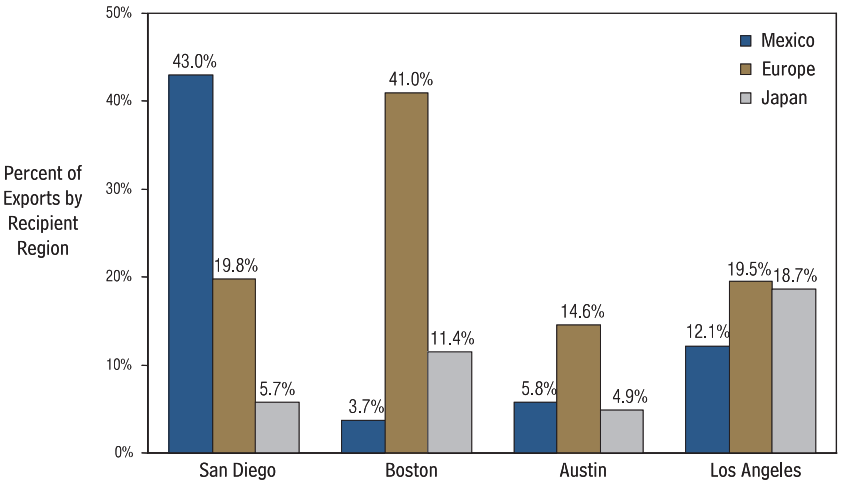


Source: 1997 US Census, Monitor Analysis

Exports. Manufactured exports are $6,415 per worker in San Diego, versus $4,603 for the United States, $6,905 for Austin, and $5,497 for Boston. Total manufactured export growth has been strong; from 1993 to 1999, San Diego has a compound annual growth rate (CAGR) of exports of 12.7%, versus 7.9% for the United States, 19.1% for Austin, and 8.3% for Boston.

General statistics on San Diego exports are, however, misleading measures of performance because much of the region's exports are television components sent to Mexico. These components are assembled and exported back to the United States. Total exports from San Diego are as much a measure of the value of having cheap labor nearby as of local competitiveness (see Exhibit 15).

Exhibit 15.
Manufactured Exports of Select Metropolitan Areas by Destination



Note: Data are for manufactured and commodity exports only
Source: U.S. Department of Commerce, International Trade Administration

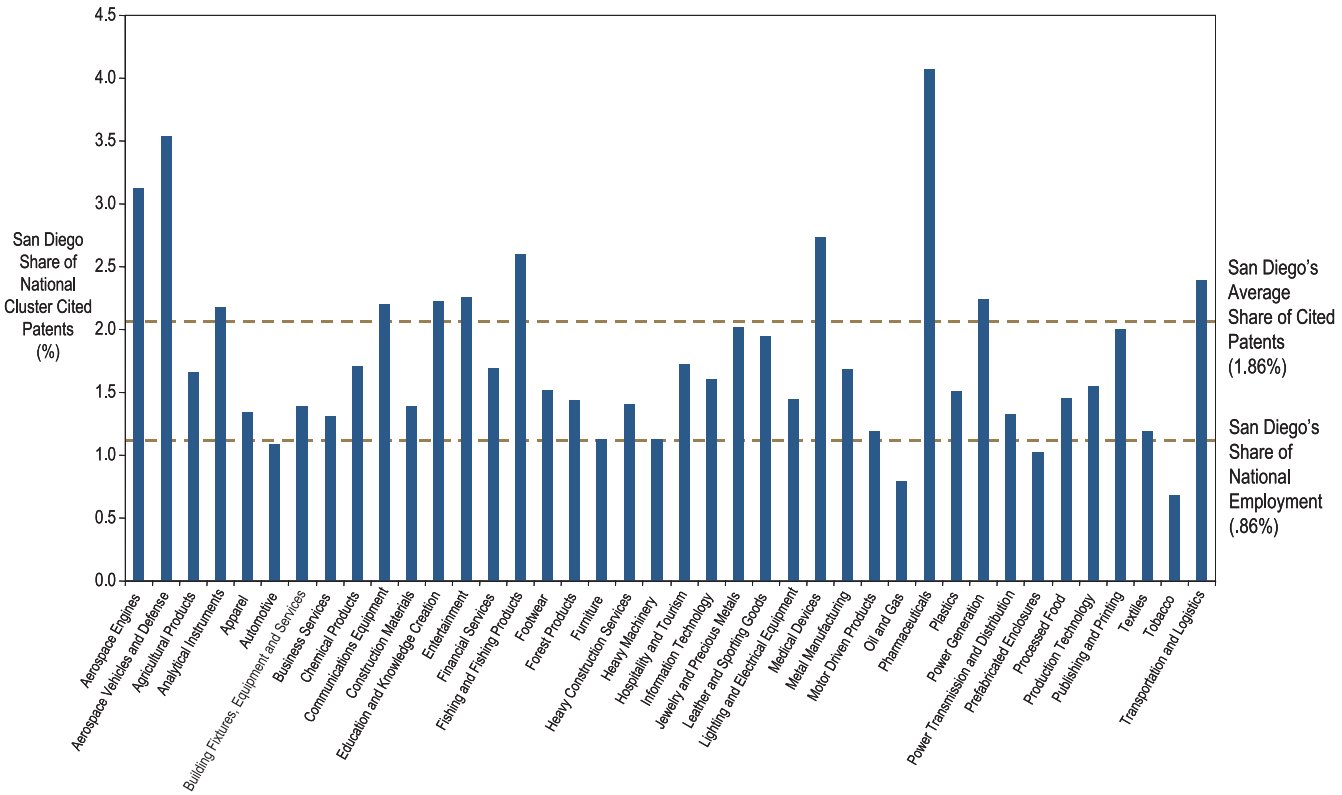
Indicators of Innovation Output

To assess potential future competitiveness, we examined measures of innovative output and entrepreneurship and compared San Diego to the nation and benchmark regions in the following metrics: patents, venture capital investments, the prevalence of fast-growing companies, and initial public offerings. Patents measure early stage innovation, whereas venture funding, fast growth firms, and IPOs measure innovation at successive stages. The San Diego economy has produced a high level of innovation output over the last decade.

Early Stage Innovation: Patent Registration. In 1999, the most recent year for which data are available, inventors in San Diego registered 1,748 patents, ranking the region eighth among U.S. metro areas. San Diego produced 12.87 patents per 10,000 workers, more than twice the national average of 6.29, but well behind competitor regions like Boston (20.93) and Austin (22.2). San Diego's annual patent growth rate of 9.67 % was seventh fastest among the 20 largest patenting regions. It was faster than the national rate of 6.54%, and Boston's rate of 7.11%, but significantly trailed Austin's 18.01%.

To measure the quality of patents, we look at the number of patents cited in other patent applications. San Diego clusters have a high percentage of quality patents (see Exhibit 16). The MSA has .86% of the nation's employment in traded industries, but has 1.86% of cited patents in traded industries. Forty-eight percent of San Diego patents are cited in other patent applications, ninth highest out of the 20 largest patenting regions. Boston had 51% of its patents cited in other applications, and Austin had 62% cited.

Exhibit 16. Percentage Share of Cited Patents in the Nation by Cluster, 1998

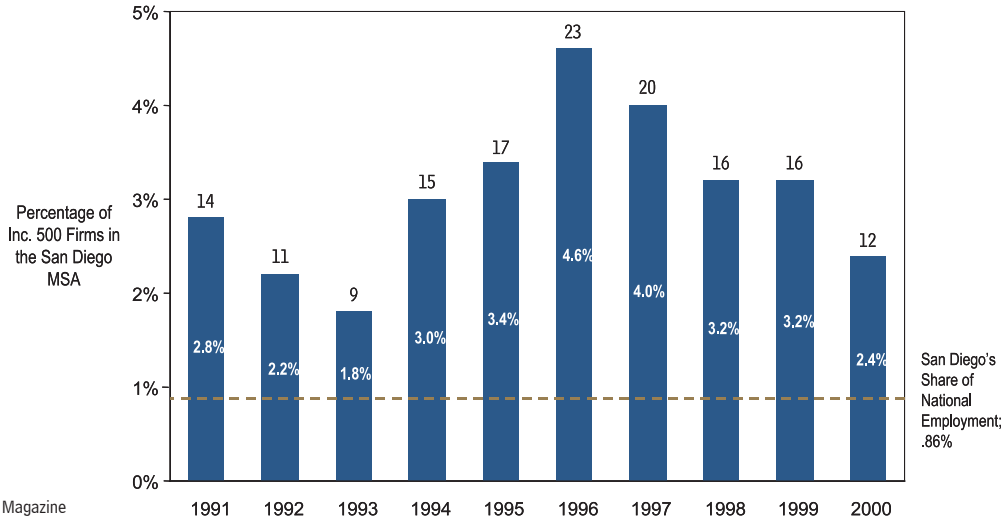


Note: Tier 1 Industries only
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

Later Stage Innovation: Venture Capital Funding, Fast Growth Firms, and IPOs. From 1995 to 1999, San Diego firms received $2.2 billion in venture capital. At roughly $674 per civilian worker in 1999, this is two-and-a-half times the national average of $266 per worker. However, San Diego lags regions such as Boston ($768 per worker in 1999) and Austin ($1,122 per worker in 1999). San Diego's compound annual growth rate of 35.6% growth of venture capital investments over this period is below the national rate of 54.7%, Boston's rate of 53.5%, and Austin's rate of 86.2%.

The San Diego MSA also has a large number of rapidly growing firms. Exhibit 17 shows the percentage of Inc. 500 companies in the San Diego MSA on the vertical axis (exact number at top of bar). In the worst year out of the last 10, San Diego had 1.8% of the Inc. 500 companies, more than twice its share of national employment. As with venture capital funding, however, San Diego's representation on this list is shrinking.

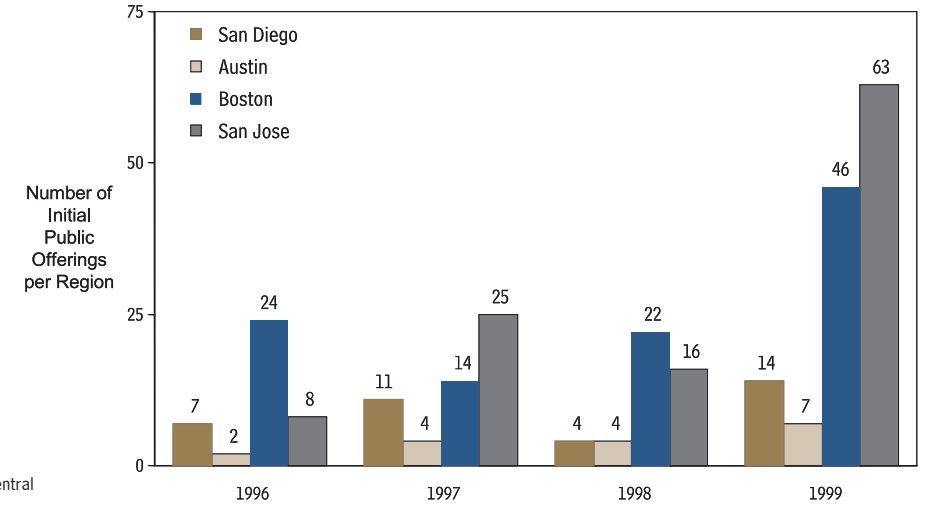
Exhibit 17.
Percentage and Number of Inc. 500 Firms in the San Diego MSA, 1991-2000



Source: Inc. Magazine

San Diego had 36 companies that went public from 1996 to 1999, more than Austin, but well behind leading regions like Boston, which had 106 IPOs, and San Jose, which had 112 (see Exhibit 18).

Exhibit 18. Number of Initial Public Offerings per Region, 1996-1999



Source: Hoover's IPO Central

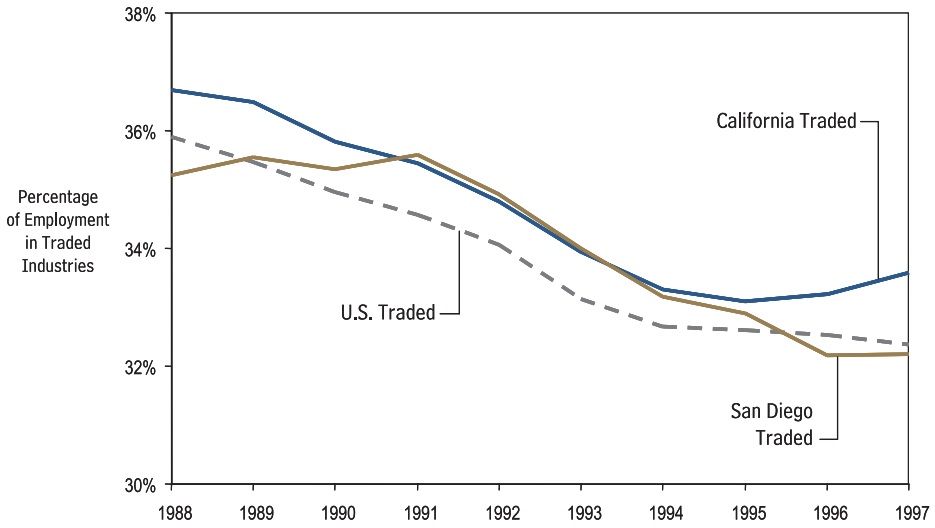
Composition of the Regional Economy

San Diego has a relatively small share of its employment in traded industries, although it does have a relatively large number of strong and growing clusters. The defense cuts eliminated many jobs in defense-related industries, which accounts for the smaller percentage of employment in traded industries. Over time, former defense workers are finding work in other clusters, and San Diego is increasing its share of employment in traded industries. As these trends continue, regional average wages will rise, and innovative output and exports should continue to grow as well.

Overall Economy. Services are the largest, fastest growing segment of the San Diego economy, accounting for 32.7% of employment in 1999, and having an annual growth rate of 4.6% from 1990 to 1999. Retail trade is also a large sector, at 17.6% of San Diego employment in 1999 with an annual growth rate of .7% from 1990 to 1999.[18] Government is the third largest sector, employing 17.2% of San Diego's workers, growing at an annual rate of 1.3%, and having most of its workers in public education.[19] Farm employment is relatively small at .8% of San Diego's employment in 1999, or 11,300 workers.

Employment in higher paying traded industries is growing in San Diego, despite the trend indicated in Exhibit 19.[20] Due to defense cuts, San Diego lost more employment in traded industries in the mid-1990s, than either the U.S. or California. However, prior to 1991, and then again in 1997 (the last year for which data are available), the rate of growth of jobs in traded industries in San Diego was faster than in non-traded industries. In 1997, San Diego traded industries grew by 5.0% compared to the national rate of 3.7%. If this trend continues, San Diego's average wages will tend to rise above national averages.[21]

Exhibit 19. Percentage of Employment in Traded Industries

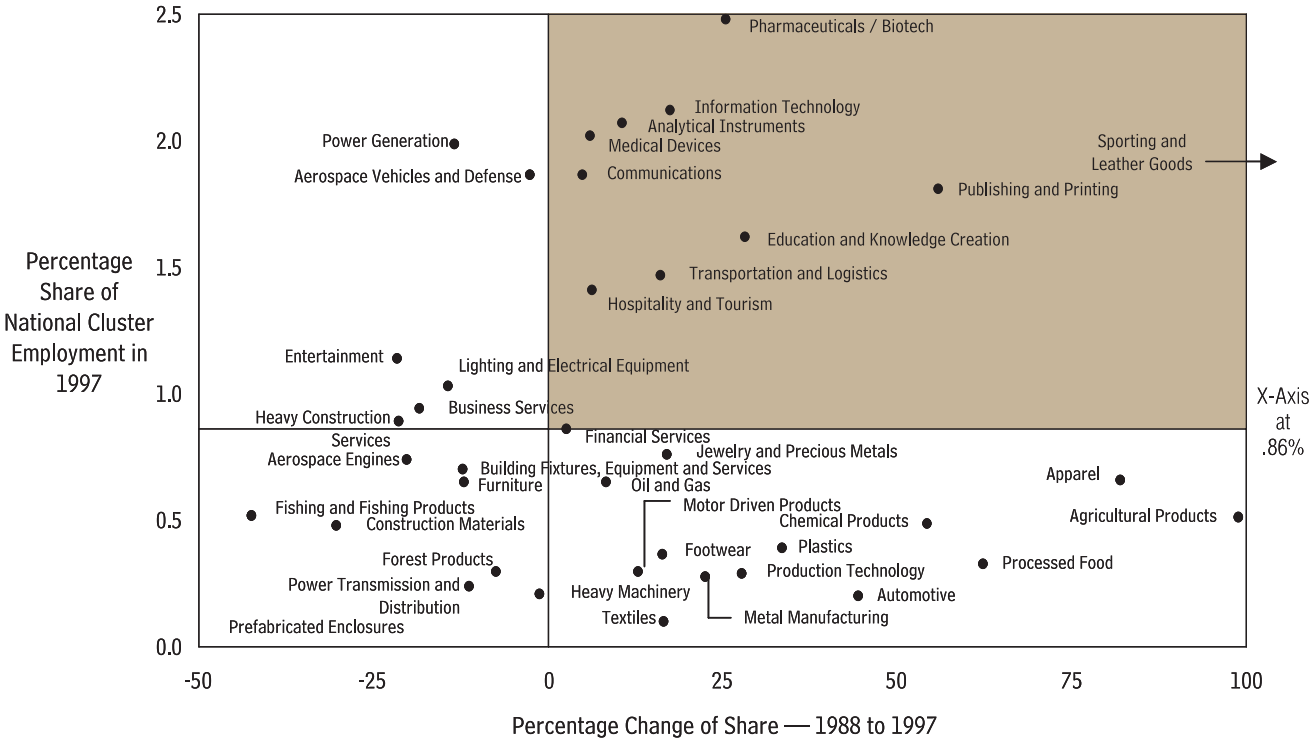


Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

[18] Data for this paragraph come from the California Employment Development Department.
[19] Government accounts for 13.6% of California's civilian employment. California Employment Development Department.
[20] Jobs in traded industries pay about $13,000 more per year than jobs in non-traded industries.
[21] Indeed, fostering growth in traded industries is the focus of groups such as the San Diego Regional Economic Development Corporation (SDREDC).

Clusters. Exhibit 20 shows San Diego's employment share and growth in the 39 traded clusters in the United States economy.[22] San Diego has .86% of total national employment, and this is the point at which the horizontal axis crosses the vertical. Clusters above the horizontal axis are relatively concentrated in San Diego, and clusters to the right of the vertical axis have grown from 1988 to1997. The upper right quadrant represents clusters in San Diego that have a relatively higher share of national employment and are growing in share of national employment. In San Diego, 47% of traded industry employment is in the upper right quadrant, a good sign for future growth potential.

Exhibit 20. Composition of the San Diego Economy by Cluster, 1988-1997



Note: Tier 2 Industries
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

[22] Due to lack of data, the fortieth and final cluster, tobacco, is not included.

THE ROLE OF THE MILITARY

In San Diego, there were roughly 94,000 men and women in uniform in 1998.[23] Although this represents more than a 15% decline from 1990 to1998, the military, and in particular the Navy, is still a large presence in the region; the communications and biotech/pharma clusters combined employ just over 60,000 people. Although wages in the armed forces and the attendant civilian service providers are not high, military personnel have high benefits, and incoming revenue is far greater than payroll alone. The military also brings considerably more tax dollars into San Diego than its people pay out. In 1999, defense spending on contracts, military payrolls, and base expenditures was nearly $10 billion.[24] The Navy is currently competing with Bremerton, WA to serve as home port for the soon-to-be completed aircraft carrier, the *Ronald Reagan*, which would bring in roughly $225 million per year to the region.[25]

The military is also a source of R&D spending. SPAWAR is headquartered in San Diego and is focused on improving communications for the Navy and other services. Despite defense cuts over the decade, SPAWAR's budget has increased. In 1999, roughly $800 million contracts were awarded to outside vendors, many of them in San Diego.[26] San Diego firms are also well positioned to compete for R&D funding from other military sources. For example, Quantum Magnetics recently received $11.9 million from the Navy to develop a land mine detection system, which is based on technology originally funded by the Defense Advanced Research Projects Agency (DARPA).[27]

A third benefit of the military presence is that the U.S. Navy has been a large and sophisticated consumer of wireless communications and other technologies for decades. Both Linkabit and QUALCOMM — to say nothing of the numerous firms that spun out from these two-initially focused on serving the military's communications needs. It is no accident that the strength of the San Diego communications cluster is in wireless communications.

Military R&D spending and its demand for finished products have been critical assets in the development of the communications and IT clusters in San Diego. The aerospace engines and aerospace vehicles and defense clusters have historically been large-employment, high-wage sectors. After the cuts of the early 1990s, employment and average wages in these clusters have been rising again. Spending on a national missile defense system will likely rise under the Bush administration. A major interest of DARPA—an agency with nearly $2 billion to spend on R&D investments — is the links between bioscience and information technology and how this could serve U.S. security.[28] San Diego has several institutions for collaboration that work to link companies with military projects, including the San Diego Defense and Space Technology Consortium, and the San Diego branches of the Armed Forces Communications and Electronics Association and the National Defense Industrial Association. Local firms are well positioned to take advantage of these and other opportunities.

Exhibit 21 shows the national ranking in terms of percentage share of national employment of each of San Diego's clusters. In 1997, San Diego was the seventeenth largest MSA, and it ranked seventeenth or higher in 10 out of 40 clusters in terms of share of national employment.

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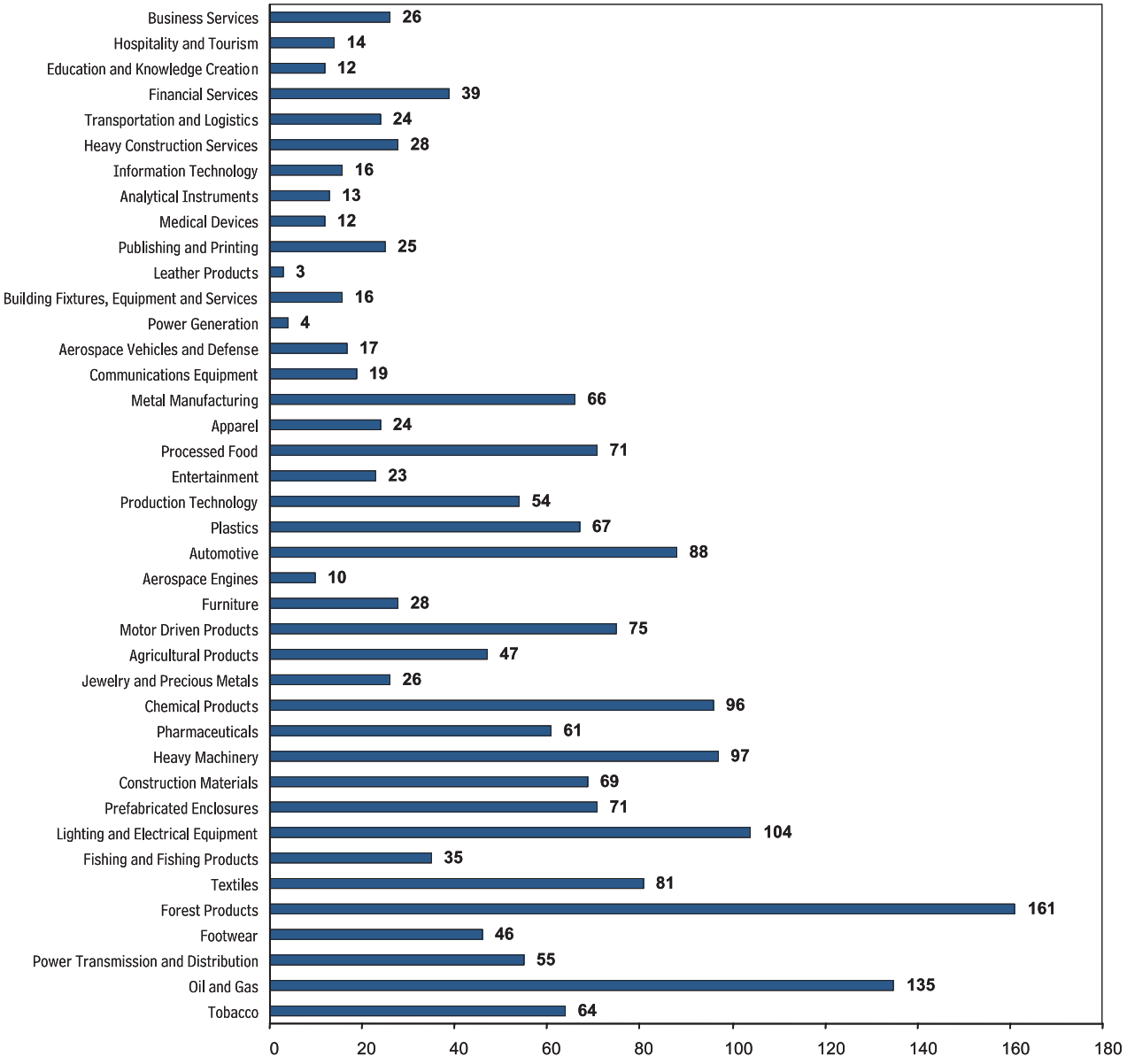
[23] SANDAG estimate (from *Developing High-Technology Communities*).
[24] San Diego Defense and Space Technology Consortium; www.sandiegodefense.com.
[25] James Crawley and Otto Kreisher, "San Diego in battle to be home port for Reagan," Copley News Service, April 9, 2001, http://www.signonsandiego.com/news/military/20010409-9999_1n9reagan.html.
[26] Tom Sprague, "SPAWAR System Center Commands Vast Communications Development Empire," San Diego *Daily Transcript*, October 19, 2000, p. 4A.
[27] See Quantum Magnetics website.
[28] See Focus 2000 on the DARPA website: www.darpa.mil

Exhibit 21. Rank of National Employment Share by Cluster, 1997



Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

TOURISM AND TRAVEL

San Diego is a destination for a variety of visitors, including convention goers, tourists traveling by both air and sea, and foreign visitors coming primarily from Mexico. In 2000, more than 15 million people stayed overnight in San Diego, and they spent $5.2 billion in the region; nearly 5% of the estimated $110.2 billion gross regional product. Tax receipts on hotel and motel rooms was $125.3 million in 2000, which was 5.8% of the 2000 Total Combined Budget of the City of San Diego.[29]

Most visitors to San Diego, 85%, come for leisure. Another 13% come on commercial (business or convention) trips. Visits by leisure travelers have increased over the past four years, while the number of convention visitors has declined. Conventions and trade shows have dropped from 59 in 1997 to 51 in 1999; convention delegate spending dropped from $257 million in 1997 to $248 million in 1999.[30] Cruise ship visitors have declined from a high of more than 500,000 in 1991 to less than 100,000 in 1997.

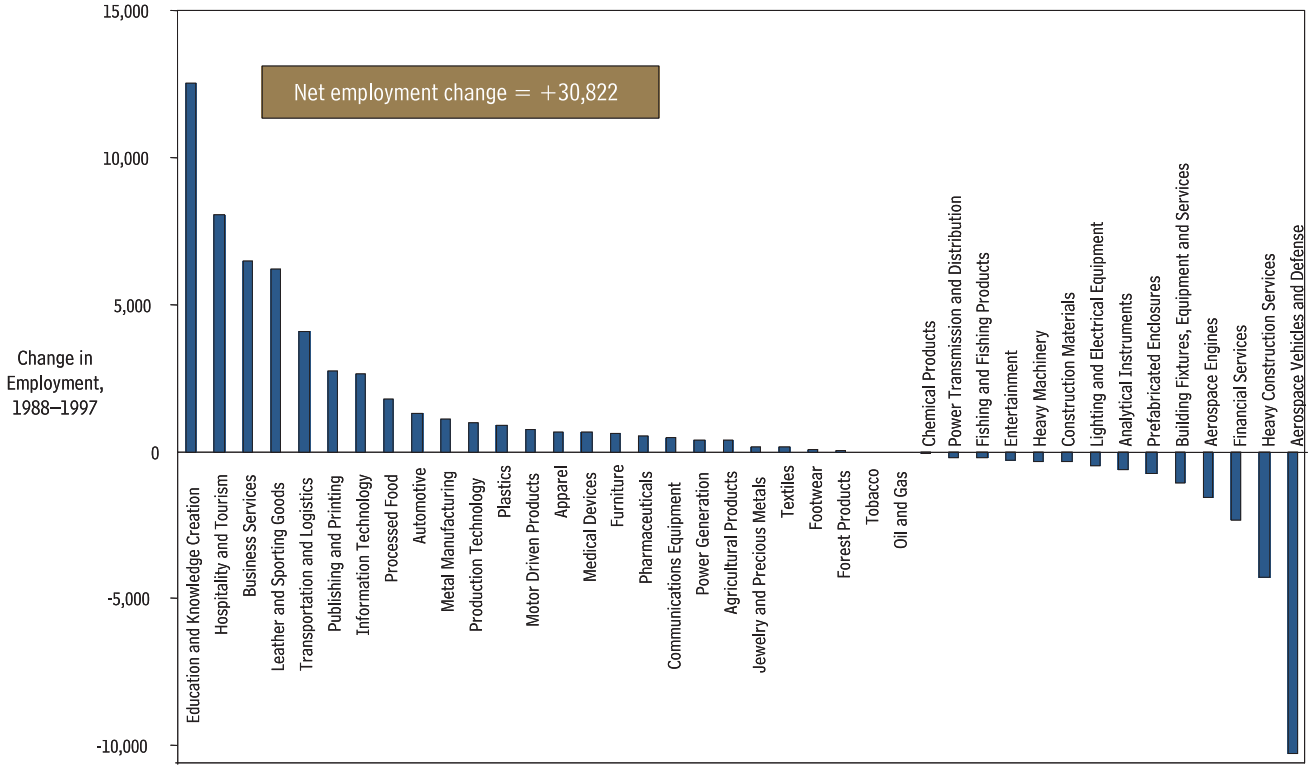
The San Diego Association of Governments (SANDAG) estimated 77,200 people were employed in Visitor Industry Services in 1998, and that annual employment growth from 1990 to 1998 was only .3%. Average wages were $15,730 in 1998, and grew by only .3% per year in real terms. The Cluster Mapping Project at the Institute for Strategy and Competitiveness at Harvard Business School (CMP) looks at the traded portion of hospitality and tourism employment, and estimates 1997 employment at 43,375, with an annual growth of 4%. Average wages for the cluster in 1997 were $20,826, which was 94% of the national average for the cluster.

Given San Diego's location in a warm and sunny climate, on the ocean, and near Mexico, it is inevitable that the county will have a large hospitality and tourism cluster. Tourism will be a large component of the economy forever, and the challenge is to upgrade it. The cluster brings in sizeable tax receipts. It also buffers the region from a recession. Even in cyclical downturns, people will take vacations, and San Diego is an attractive and relatively inexpensive destination. Although wages in the cluster will always remain below regional average wages, they need not remain below average for the cluster nationwide. To increase wages, productivity must rise, the quality of attractions needs to be improved, hotels should provide a level of service that enables them to raise room rates, and so forth. Increasing the number of convention and business visitors is the obvious way of doing it. On average, a commercial visitor spends more than twice what a leisure visitor spends per day, and stays slightly more days per trip. After a large increase in delegate attendance and spending from 1996 to 1997, these numbers have been declining. This is a point of concern for the cluster.

Exhibit 22 shows the growth and decline in employment in San Diego's clusters from 1988 to 1997. The net gain in employment in traded industries over the period was 30,822 jobs.

[29] San Diego Convention and Visitors Bureau, and the Official Website of the City of San Diego; www.sannet.gov.
[30] San Diego Convention and Visitors Bureau.

Exhibit 22. Employment Growth and Decline by Cluster, 1988 to 1997



Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

MEXICO

The proximity of Mexico shapes the composition and influences the performance of the San Diego economy in a number of ways. A comparison of six border MSAs in the United States, including San Diego, indicates that proximity to Mexico tends to pull down average wages.[31] Sharing a border with Mexico also boosts exports, particularly after the implementation of North American Free Trade Agreement (NAFTA). Many of these exports from San Diego are unfinished television components sent across the border where they are assembled and then re-exported back to the United States. Nearness to Mexico tends to increase employment growth, particularly in the retail, government, and transportation sectors. Certainly this is borne out in San Diego, where the retail and government sectors are projected to add jobs faster than other sectors, and where the transportation and logistics cluster has a relatively high share of national employment. Finally, U.S. border areas tend to have less manufacturing.

Mexico undoubtedly affects San Diego's economy, and effort is needed to prosper from cross-border influences. One set of opportunities for mutual collaboration is infrastructure issues. For example, the Tijuana river flows from the United States into Mexico, where it picks up waste from both manufacturing plants and communities which lack adequate sewage disposal. The river then flows back into the United States and enters the Pacific at Imperial Beach, CA. The water treatment plant at the re-entry point does only primary treatment, and cannot handle the water volume when it rains. Cross-border cooperation will be necessary to solve this and other environmental issues

Another example is energy.[32] Manufacturing in Mexico drives up regional demand for energy, which raises prices on both sides of the border. In 1996, Mexico stopped exporting energy to San Diego due to its own rising demand. Tijuana's main power plant in Rosarito is less than 15 miles from the border, burns heavy oil, and is a major source of pollution in the region. On a more positive note, Mexico may be able to provide power to California in the near future. As with airports, building new energy plants in the United States often meets with local opposition, and again this obstacle is less serious in Mexico. NAFTA enables U.S. companies to produce and sell energy in Mexico, and potentially to U.S. consumers as well. The economic and environmental effects of the energy market are felt on both sides of the border, and resolving issues in a positive way will require greater cross-border collaboration.

A third issue is expanding airport facilities. Little progress has been made on this issue in San Diego over the last 3 decades. A significant obstacle on the U.S. side of the border has been opposition to airport construction and expansion by local communities which do not want the added road congestion and

[31] James Gerber and Sergio J. Rey, "The Employment Dynamics of Regional Economies on the U.S.-Mexico Border," Spring 2001.

[32] Data for this paragraph are drawn from Alan R. Sweedler, "Energy Issues in the San Diego/Tijuana Region," Briefing paper prepared for San Diego Dialogue's Forum Fronterizo policy luncheon series (November 1999).

noise in their neighborhoods. A potential solution is to jointly develop Rodriguez Field, which lies in Baja California and nearly touches the U.S. border. There is precedent for an international airport; Basil ,Switzerland operates an airport shared by Germany, France, and Switzerland. Certainly coordinating with the respective federal departments responsible for foreign relations and air traffic regulations in both Mexico and the United States will not be easy; then again, neither is collaborating with the numerous political bodies in San Diego County.

A second set of opportunities is presented by the large manufacturing presence just across the border. Better linkages with Mexico would spur the growth of a number of industries and clusters in San Diego. Cross-border supplier networks could certainly be strengthened, as could engineering and design services. There is already a sizeable transportation and logistics cluster in San Diego that could be further augmented by becoming a hub for north-south trade. Clusters like business services and financial services are large and growing, and proximity would give them a powerful strategic advantage in providing services to Baja California's industries. "High-tech" clusters like biotech/pharma and communications are important sources of job creation, but they cannot employ the vast majority of San Diego's growing population. For San Diego's economy to be successful, large clusters like business services, financial services, and transportation and logistics will have to provide those jobs.

A third set is opportunities offered by increasing linkages with Mexico beyond the border region. Mexico has a per capita GDP of about $8,500, a GDP growth rate of 3.7%, and a literacy rate of 90%. This is comparable to countries such as Argentina ($10,000 per capita GDP, -3% growth, and 96% literacy) and Poland ($7,200 per capita GDP, 3.8% growth, and 99% literacy).[33] San Diego companies are well positioned to succeed in this growing market, as well as Latin American markets more generally. The hospitality and tourism cluster would benefit from increased foreign tourism, which would tend to increase spending per visitor. Local colleges and universities could cater to foreign students. The heavy construction services, communications, and power generation clusters could access a large market with strong demand for the upgrading of infrastructure. Health care providers could realize strong growth in markets with poor current service and governments faced with wide-ranging demands on their resources. In general, the long-term growth potential of developing countries like Mexico is greater than that of developed countries like the United States. San Diego companies are well positioned to benefit most from this growth.

Exhibit 23 shows employment and wage data from the Tier 1 industries of the 20 largest clusters in San Diego.[34] The 10 light blue highlighted clusters are large and have been growing at or above the regional average. They have created 87% of the new jobs in traded industries in San Diego from 1988 to 1997.[35] These 10 clusters are the primary drivers of wealth creation in San Diego. However, only four them pay wages higher than the regional average (highlighted in blue).

This Exhibit again shows the innovative strength of San Diego, with 13 of the clusters having a higher per capita patenting rate than the national average, and 19 increasing their patenting rate faster than the national average (highlighted in gold).

33 Central Intelligence Agency, World Factbook 2000, http://www.odci.gov/cia/publications/factbook/indexgeo.html

34 Industries appear in more than one cluster (e.g., noncommercial research institutions are in both biotech/pharma and communications). One consequence of this is that employment totals of several clusters double-counts some workers. To solve this problem, the CMP identified Tier 1 industries. All industries are Tier 1 industries in one cluster, and one cluster only. In addition, many industries are Tier 2 industries in other clusters. For example, noncommercial research institutions are a Tier 1 industry in the education and knowledge creation cluster, and are a Tier 2 industry in several other clusters, including biotech/pharma and communications.

35 46,466 jobs out of the 53,600 total created.

Exhibit 23.
Employment, Wage and Patent Metrics of Tier 1 Industries for San Diego's 20 Largest Clusters

Cluster	Total Employment 1997	Annual Growth Rate in Employment 1988-1997	Average Wages Indexed to Nation 1997	Annual Growth Rate of Average Wage Index 1988-1997	Patents per Employee Indexed to Nation 1997	Annual Growth Rate of Patent Index 1988-1997
Business Services	43774	1.80	104.63	.13	169.63	1.65
Hospitality and Tourism	31957	3.28	95.52	-.12	148.97	.91
Education and Knowledge Creation*	29275	6.39	153.64	1.53	121.67	1.35
Financial Services	22276	-1.10	77.04	-1.86	207.64	1.79
Transportation and Logistics	18798	2.77	88.62	-.29	110.31	1.04
Heavy Construction Services	18421	-2.28	102.30	-.02	120.47	1.80
Information Technology	15569	2.08	98.42	1.80	78.45	1.26
Analytical Instruments	14392	-.46	98.57	.69	87.17	1.43
Medical Devices	10451	.71	96.74	-1.28	104.50	1.50
Publishing and Printing	9312	3.92	91.96	-1.28	96.14	1.71
Sporting and Leather Goods	9095	13.48	144.36	2.44	89.67	1.94
Building Fixtures, Equipment and Services	9070	-1.74	100.48	.81	207.33	1.64
Power Generation	8290	.56	68.94	2.15	62.39	1.19
Aerospace Vehicles and Defense	5001	-11.65	106.32	.64*	90.79	1.31
Communications Equipment	4837	1.14	108.81	4.16	94.41	1.38
Metal Manufacturing	4716	3.05	85.04	-.11	429.06	1.34
Apparel	4604	1.71	110.27	2.85	246.13	2.28
Processed Food	4520	5.65	105.62	5.49	341.16	2.16
Entertainment	4042	-.57	102.14	4.40	183.80	1.54
Production Technology	2835	4.28	83.17	-.49	450.32	1.41
Cluster Outperforming National Average	----	----	10	12	13	19

Note: * includes commercial and noncommercial research organizations, most of which are focused on biotech.
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

Industries in San Diego. Exhibit 24 shows the ten industries in San Diego that added the most jobs to the economy between 1988 and 1997. Three are in manufacturing-sporting goods, computer peripheral equipment, and shipbuilding and repairing, while the others are service or knowledge creation industries. Exhibit 24 also explains the growth in sporting and leather goods cluster in San Diego. A number of local companies that design and manufacture golf equipment (e.g., Callaway) have pioneered the use of lightweight materials originally used in defense applications. This innovation has generated strong growth for the sporting and athletic goods industry.

Exhibit 24. Ten San Diego Industries with the Most Employment Growth, 1988 to 1997

Industry	Commercial Physical Research	Hotels and Motels	Sporting and Athletic Goods, n.e.c.	Prepackaged Software	Computer Peripheral Equipment, n.e.c.	Colleges and Universities	Information Retrieval Services	Local and Suburban Transit	Computer Related Services, n.e.c.	Shipbuilding and Repair
Clusters in which Industry Features	Aerospace Vehicles and Defense Analytical Instruments Communications Education and Knowledge Creation Information Technology Medical Devices Pharmaceuticals Publishing and Printing	Hospitality and Tourism	Leather Products	Aerospace Vehicles and Defense Analytical Instruments Communications Education and Knowledge Creation Financial Services Information Technology Medical Devices Publishing and Printing Transportation and Logistics	Analytical Instruments Communications Education and Knowledge Creation Information Technology Medical Devices Transportation and Logistics	Education and Knowledge Creation	Business Services Communications Education and Knowledge Creation Financial Services Information Technology Medical Devices Publishing and Printing Transportation and Logistics	Hospitality and Tourism Transportation and Logistics	Aerospace Vehicles and Defense Analytical Instruments Business Services Communications Education and Knowledge Creation Financial Services Information Technology Publishing and Printing	Transportation and Logistics
Total Employment Gained in Region 1988 to 1997	6,999	6,690	4,894	3,440	3,190	2,298	1,806	1,748	1,609	1,577

Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

The same shift from manufacturing toward services and knowledge creation is seen by looking at the declining industries in the region. Of the ten that lost the most jobs, six are in manufacturing and two are in construction.

Exhibit 25. Ten San Diego Industries with the Largest Employment Decline, 1988 to 1997

Industry	Guided Missiles and Space Vehicles	Aircraft Parts and Equipment, n.e.c.	Savings Institutions	Semi-conductors and Related Devices	Concrete Work	Electronic Computers	Search and Navigation Equipment	Plastering, Drywall, and Insulation	Household Audio and Video Equipment	Air Transportation Scheduled
Clusters in which Industry Features	Aerospace Vehicles and Defense Communications	Aerospace Vehicles and Defense Aerospace Engines	Financial Services	Aerospace Vehicles and Defense Analytical Instruments Communications Information Technology Medical Devices	Heavy Construction Services	Aerospace Vehicles and Defense Analytical Instruments Communications Education and Knowledge Creation Information Technology Medical Devices	Aerospace Vehicles and Defense Analytical Instruments Communications Education and Knowledge Creation	Heavy Construction Services	Communications Entertainment	Transportation and Logistics
Total Employment Lost in Region 1988 to 1997	-7,125	-3,494	-2,720	-1,912	-1,775	-1,748	-1,686	-1,651	-1,375	-1,270

Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

REGIONAL INNOVATIVE CAPACITY

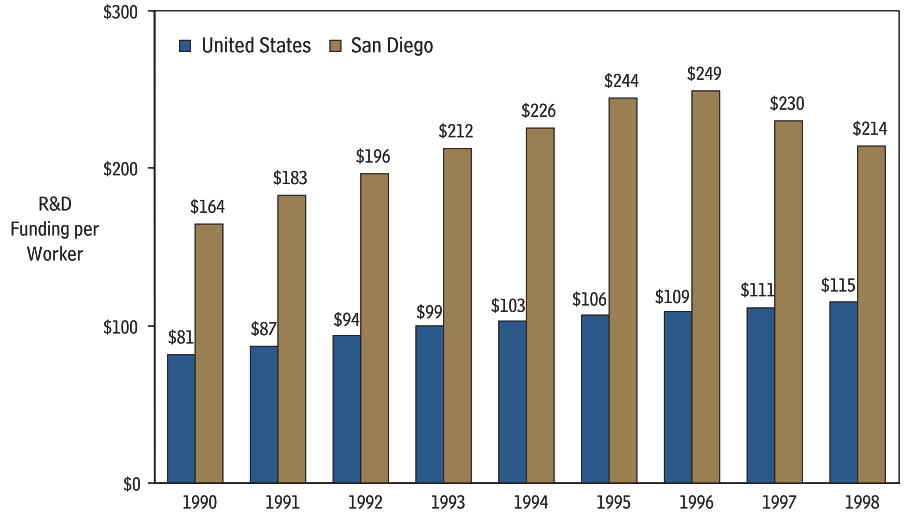
For decades, the San Diego economy has been significantly influenced by the U.S. Navy, Mexico, tourism, and the aerospace and defense clusters. Recently, the composition of the economy has been shifting more and more into knowledge-intensive, service-oriented, traded clusters. This section uses the diamond framework to assess regional innovative capacity, in order to explain shifts in the composition of the regional economy and determine whether the business environment will support all important components of the regional economy.

Some factors affect the business environment of specific clusters, while others are important across all clusters in the region. This section focuses on the latter. In particular, we assess basic and specialized inputs (investment in R&D, skilled workers, quality of education, physical infrastructure, availability of risk capital, and quality of life), government policy, institutions for collaboration, and attitudes toward business. San Diego's primary strengths are its superior research and training institutions, large pool of scientists and skilled workers, and formal and informal institutions for collaboration. These assets largely explain the shift of employment into knowledge-intensive, service-oriented, traded clusters. Factors having little positive effect have been the local physical infrastructure, the supply of risk capital, the K-12 educational system, and the scarcity of management and marketing expertise. The main challenges for the future will be to preserve and improve the local quality of life in order to continue attracting human capital, to reinvigorate government action, and to preserve and strengthen the links between research institutions and industry.

Basic and Specialized Factor Inputs

Investment in Research and Development. San Diego leaders have been successful in attracting research institutions to the metro area. A good indicator of the level of local investment is federal R&D expenditures to universities. Standardizing by the number of workers, San Diego consistently receives more than twice the national average of R&D investment per worker (See Exhibit 26).

Exhibit 26. Federal Funding for University R&D per Worker, 1990 to 1998

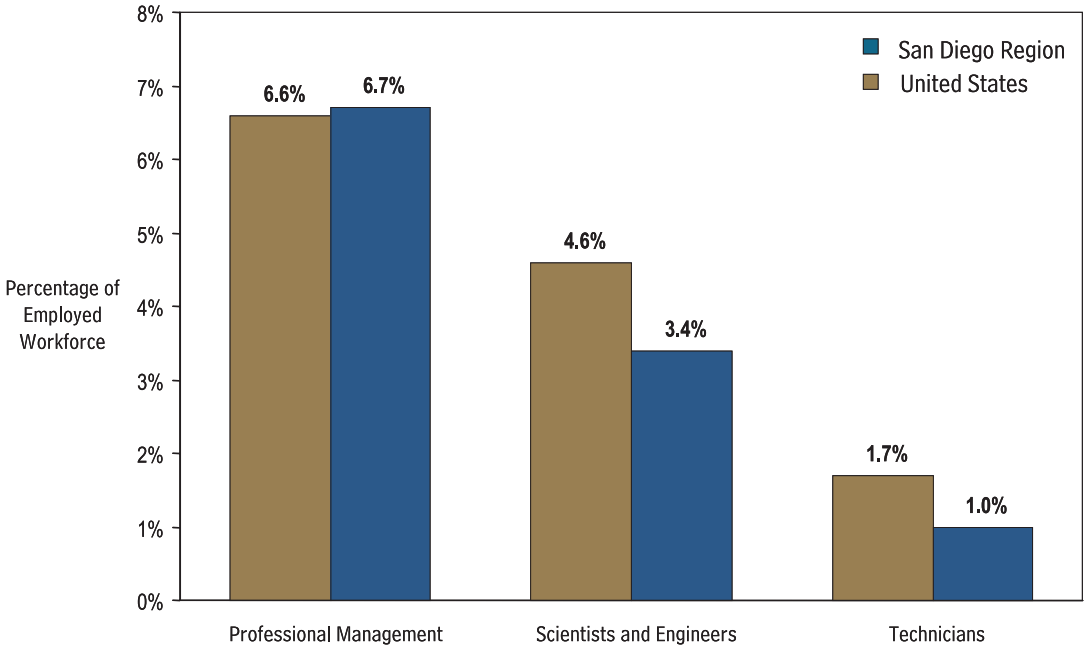


Source: NSF WebCASPAR Database System, U.S. Bureau of Labor Statistics

Eighty-seven percent of those surveyed reported that local research centers were readily available to support research and development needs, and 69% said they frequently transferred knowledge to the private sector.[36]

Skilled Workforce. Exhibit 27 shows that there is a relatively large number of scientists, engineers, and skilled technicians in San Diego. Surveys and interviews also indicate that many firms came to San Diego because of the labor pool.

Exhibit 27. Skilled Workforce Base in San Diego and the United States, 1998



Note: **Professional Management** includes Staff and Admin Specialty Managers, Line and Middle Management Managers, Other Managerial and Administrative Positions; **Scientists and Engineers** includes: Engineers and Related Occupations, Natural Scientists and Related Occupations, Computer, Mathematical, Operations Research, and Related Occupations, Economists; **Technicians** includes: Technicians and Technologists in Scientific and Engineering Related Occupations

One weakness — as indicated by Exhibit 27, survey respondents, and interviewees — is that firms must recruit managers and marketers from outside the area. Professional management makes up 6.6% of San Diego's workforce, 6.7% of the United States', and 9.6% of Austin's.

In 1997, the region produced approximately 1% of the total U.S. advanced and bachelors degree holders in the hard science and engineering fields.[37] In that year, San Diego had 1.21% of the nation's scientists, engineers, and related technicians; it had 1.16% of the nation's upper level scientists and engineers.[38] These data support a concern commonly expressed in interviews that that the region will have trouble replenishing its pool of scientists, engineers, and technicians. Fifty-one percent of survey respondents stated that increasing the supply of skilled workers was important to their business's success (third mostly frequently cited concern), and 33% said the same of scientists and engineers (fifth most frequent).

[36] Clusters of Innovation Regional Survey
[37] NSF Caspar Database.
[38] NSF Caspar Database.

Quality of Education. The quality of K-12 education in San Diego appears to be at, or slightly above, national averages. Between 1994 and 1999, San Diego's graduation rate of 87% exceeded both state and national averages (80% and 84% respectively).[39] Since 1990, San Diego students' SAT scores have tracked the national averages, with both San Diego and the nation averaging a 1016 (out of 1600 total possible) in 1999. San Diego's average student/teacher ratio is 20.3, while California's is 21.6, and the United States' is 16.8. San Diego and California have reduced their student/teacher ratios by over 12% since the 1994 to 1995 school year.[40]

Physical Infrastructure. San Diego has a good communications infrastructure (85% of survey respondents said it satisfied their business needs), and despite frequent complaints, relatively good traffic flow.

Air transportation, however, is a problem. Although San Diego International Airport is centrally located, it lacks both frequent and direct flights to many destinations. Population and economic growth will create increased demand for air transportation. A recent study estimated that by 2030, the cumulative opportunity cost of not expanding regional facilities was between $29.6 billion and $93.8 billion.[41] In 2030, there would be 34,000 to 56,000 fewer jobs. More than half of the job losses, and more than 75% of the lost gross production would occur in innovative clusters, such as communications and biotechnology. A number of biotech firms now anticipate increased need for air transport as their products become ready for commercial distribution.

A second weakness of infrastructure is ensuring reliable, cost-competitive access to power and water. Southern California is dry, heavily populated, and growing rapidly. Water is a perennial issue in the state, and demographic shifts guarantee that it will remain so. More recently, deregulation of the state's energy industry has led to short supplies, higher energy prices, and even rolling blackouts throughout the state. Although Northern California has been hit the hardest, rising utility prices affect the entire state.

Supply of Risk Capital. Although local risk capital is much more plentiful in San Diego than five years ago, it is not abundant. Survey respondents report that getting capital is neither difficult nor easy. Interviewees are also equally split between those reporting adequate funding versus those who report inadequate funding.

Quality of Life. Interviewees consistently rate the San Diego quality of life as a significant asset in developing the economy. Its location on the Pacific, warm and sunny climate, small-town feel, and close proximity to Los Angeles and Mexico make San Diego more able than most regions to attract and retain quality workers. More than any other factor, survey respondents cite quality of life as the main reason companies locate in the metro area.

At the same time, respondents express concern over the future quality of life. Population growth, traffic, pollution, and housing prices are degrading the regional quality of life. It is not clear that this historical asset will remain the strong attraction it has been in the past.

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39 California Department of Education and National Center for Educational Statistics.

40 Texas Transportation Institute, Texas A&M University, 1999 Annual Mobility Report.

41 "The Impacts of Constrained Air Transportation Capacity on the San Diego Regional Economy," Hamilton, Rabinovitz, and Alschuler, Inc., January 5, 2001. The lower estimate assumed maximum expansion of SDIA, while the higher estimate assumed no change to existing facilities.

The Role of Government

Government actions — by federal, state, or local agencies — affect innovation through their influence on elements of the diamond. Exhibit 28 summarizes the most important government influences on the San Diego regional economy.

Exhibit 28. Government Actions and the Diamond Framework

Element of the Diamond	Federal Government	State Government	Local Government
Factor Inputs	+ High Levels of R&D funding (SPAWAR, NIH), both past and present + Defense cuts released talent for high-tech start-ups	+ Founded UCSD + Funds San Diego State University, and Community College + Increasing funds for engineering school – Energy policies deter building of new capacity – Average K-12 education – CA Coastal Commission regulations discourage facilities expansion	+ Zoned Torrey Pines Mesa for research + Provided land on favorable terms (e.g., Salk, General Atomics) – Lack of coordination and leadership prevents maintenance and improvements of infrastructure (e.g., roads, schools, airport)
Demand Conditions	+ U.S. Navy is a sophisticated customer of wireless technology	– State FDA regulations different from Federal FDA regulations	
Related and Supporting Industries			
Context for Firm Strategy and Rivalry	+ Defense cuts refocused firms on civilian markets	– Inadequate state and local tax incentives to encourage R&D investment	

Source: Clusters of Innovation Initiative Regional Survey, and interviews

Governments' most significant positive impact has been the upgrading of factor inputs. Local and state efforts brought military and bioscience research and training facilities to San Diego; state and federal governments funded (and continue to fund) R&D as well as training programs. These actions have been, and continue to be, critical for San Diego's economic success. A second positive influence has been the military's demand for wireless communications. The U.S. military was the most sophisticated consumer of this technology for decades, and without it, the San Diego communications cluster might never have emerged.[42]

[42] Many interviewees also report that local government has gotten much better at streamlining permitting and facilitating construction.

Governments' main negative influence concerns the maintenance of quality factor inputs. State actions contribute to a poor energy infrastructure, average K-12 education, and high costs of building facilities. Local governments' poor coordination make it difficult to solve infrastructure issues like upgrading roads, schools, and the airport. For example, development of airport, port, and rail facilities are the responsibility of limited-purpose special authorities — the Port District and the Metropolitan Transportation Development Board (MTDB)— not centralized city agencies as is the case in Los Angeles, San Francisco, and Seattle. Regarding air transport, the Port District has authority over Lindbergh Field, the City of San Diego has authority over Brown Field, and SANDAG is responsible for regional planning. SANDAG is itself composed of representatives of 18 cities and the county, as well as representatives from seven advisory agencies. Progress on infrastructure issues is often perceived of as being too slow, and despite several proposals to consolidate authority over transportation planning and decision-making, little progress has been made.[43]

Regional Institutions for Collaboration

Institutions for collaboration facilitate the flow of information and resources within and among clusters (e.g., university technology transfer offices connect commercializable research with entrepreneurs). Proximity naturally creates opportunities for interaction, and institutions for collaboration can bolster these interactions. Although some regional level collaborative institutions in San Diego have been important and highly successful in the past, it is questionable whether the current set of formal and informal institutions will be sufficient in the future.

By 1970, the knowledge and human resources necessary to build many business clusters existed in San Diego. But the scientists and engineers who possessed commercially viable research ideas lacked business skills and access to risk capital. Furthermore, these resources were scarce in San Diego. UCSD CONNECT was founded in 1985, gathered business know-how, and brought together researchers, entrepreneurs, and investors. Interviewees consistently cited CONNECT, and its first director, the late William Otterson, as a key source of San Diego's success. As one interviewee noted, "Otterson taught US how to network," and a legacy of this is strong informal networks throughout the community.

USD CONNECT

In response to private sector efforts to better integrate with the University of California at San Diego, University President Richard Atkinson asked Mary Walshok, Dean of Extended Studies and Public Programs, to develop a program that would facilitate university-business interaction. After coordinating with both university researchers and private sector managers, UCSD CONNECT was established in 1985. Initial programs included:

Business Environment Assessment. CONNECT sponsored a study to determine what business leaders felt were the major gaps hindering their success in San Diego.

[43] Steven P. Erie and Charles Nathanson, "The Challenge of Developing the Cross-Border Region's Trade Infrastructure," Briefing Paper prepared for San Diego Dialogue's Forum Fronterizo, May 2000.

Meet the Entrepreneur and Meet the Researcher Events. One of the findings of the initial study was that entrepreneurs and scientific researchers had very little understanding about the issues that each faced, or the way each conducted their operations. There was almost no connection between the two groups, but as initial events that attracted hundreds of participants showed, there was a lot of interest in learning about each other.

Financial Forums. These forums brought leading capital providers to the region and educated them about San Diego companies in order to encourage investments. The forums also connected entrepreneurs with business support services (law, accounting, and marketing firms) to help them develop and present more effective business proposals.

In addition to the formal organization of UCSD CONNECT, many informal institutions developed in the 1970s and 1980s that proved instrumental in connecting individuals in the business, academic, and government communities in San Diego. Interviews reveal important informal networks created in companies like Linkabit and Hybritech, in labs like General Atomics, and in educational programs like MIT. These networks also helped entrepreneurs access scarce capital and business knowledge.

- The San Diego Regional Economic Development Corporation (SDREDC) is a county-wide organization with members from all of San Diego's industries. It tracks economic trends, works with local, state, and federal agencies on issues of concern to the business community, fosters regional collaboration, and conducts nationwide marketing of San Diego.
- The San Diego Association of Governments (SANDAG) includes representatives from the communities and major governmental bodies in San Diego County. It facilitates regional cooperation on projects that cross government jurisdictions, and generates economic information that is used by businesses and government to develop growth strategies.
- The San Diego Regional Technology Alliance (SDRTA) is a state-established organization that was formed to help established firms convert to civilian projects. Today it is focused on developing small technology businesses in downtown San Diego, by providing business advisory services and small grant programs to start-up companies.

For a more comprehensive listing of collaborative institutions in San Diego, see Exhibit 29.

Exhibit 29.
Institutions of Collaboration in San Diego

Private Sector	Joint Private / Public
Employment	San Diego Regional Economic Development Corporation
Cluster Specific Organizations (e.g., BIOCOM)	San Diego Regional Technology Alliance
San Diego Chamber of Commerce	Center for Applied Competitive Technologies
San Diego MIT Enterprise Forum	San Diego World Trade Center
Corporate Director's Forum	
San Diego Dialogue	
Service Corps of Retired Executives, San Diego	

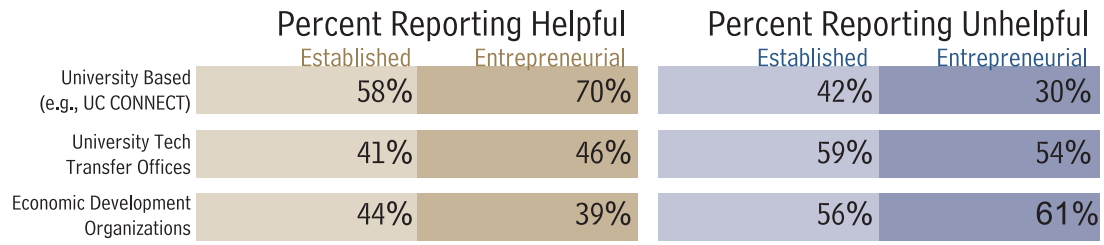
Informal Networks	Public Sector
Linkabit Alumni	San Diego Association of Governments
Hybritech Alumni	San Diego Science and Technology Council
UCSD Alumni	Office of Trade and Business Development
Scripps Research Institute	Small Business Development and International Trade Center

Source: Interviews, organization's websites

Institutions for collaboration have been important factors encouraging the development of San Diego's economy. The human assets and basic research needed to grow knowledge-based clusters existed in San Diego by the early 1970s. Yet it was not until the late 1980s, after informal networks had grown and after UCSD CONNECT was founded, that these types of clusters took off. Despite the importance, large number, and past success of collaborative institutions in San Diego, it is questionable whether the region has the right types of collaborative institutions for the future.

There are several reasons for this. First, aside from UCSD CONNECT, none of the formal regional level institutions receives high approval ratings in our Clusters of Innovation Initiative Regional Survey (see Exhibit 30).[44] Second, Bill Otterson was clearly an important asset at UCSD CONNECT, and his absence will be missed. Third, CONNECT is currently widening its mission to assist established firms as well as start-ups. Although our survey and interviews indicate that a high-quality collaborative institution serving established firms would be welcome, there is a danger that it will lose focus and enervate its impact. CONNECT is currently the only highly rated regional institution, and it is accomplishing the vital and difficult tasks of assisting start-up companies and linking the region's primary research university to the business community. Adding responsibilities will be no mean feat. Fourth, informal institutions will tend to become less effective in the future, as San Diego's economy grows and diversifies. Given the historical importance of formal and informal collaborative institutions to San Diego's economic development, maintaining and diversifying these assets should be a top priority.

Exhibit 30. Reported Helpfulness of Regional Institutions for Collaboration



Source: Clusters of Innovation Initiative Regional Survey

Attitudes toward Business

Since World War II, San Diego's leaders have sought to build a knowledge-based economy where basic research from institutions such as UCSD, Scripps, Salk, General Atomics, and others would translate into commercial products. Success depended not only on institutions for collaboration like CONNECT, but also on the attitudes of scientists and engineers doing basic research. If these individuals were uninterested in working with industry, even the best collaborative institutions would fail to bring the two groups together.

[44] Some cluster-specific institutions such as BIOCOM receive high marks in the Clusters of Innovation Initiative Regional Survey.

At first, there was not a widespread interest in collaborating with the private sector. For example, when Ivor Royston and Howard Birndorf first founded Hybritech, Royston was required by UCSD Faculty Senate rules to limit his "consulting" to Hybritech to 20% of his time, and many fellow faculty members expressed deep concern about possible conflicts of interest and his commitment to the university.[45] Similar reservations were expressed by academia when the Scripps Research Institute accepted $50 million from Eli Lilly in the early 1980s, in exchange for right of first refusal on research developments.

Several factors contributed to a change in attitudes. The passage of the Bayh-Dole Act in the early 1980s encouraged universities to take a more aggressive approach to technology transfer. New UCSD Chancellor Richard Atkinson, a former Stanford engineering dean, brought a pro-commercialization stance from Palo Alto. UCSD CONNECT and Bill Otterson made it easier for academics to start businesses. Finally, the successes academic entrepreneurs were having with Hybritech, Linkabit, and their spin-offs encouraged others to follow.

Numerous interviewees state that entrepreneurial attitudes among researchers are common and important for San Diego's success. Some leaders, however, perceive a shift back to a focus on pure science among younger researchers.

45 Interview with Ivor Royston, January 6, 2000, San Diego.

4 COMPETITIVENESS OF SELECTED CLUSTERS

This report looks at competitiveness with an emphasis on innovation. We have shown how regional economic performance and innovation output derive from the composition of the economy, and how the composition, in turn, depends upon the regional business environment. To assess the business environment, we used the diamond framework. This same methodological approach guides our analysis of clusters in San Diego.

Many factors that foster innovation are best understood by analyzing business clusters. Economic performance and innovative capacity vary among clusters, even within a region. Some elements of the diamond are more relevant for analyzing economies at the regional level. Other elements are more cluster specific. Sophistication of demand, context for firm rivalry, and related and supporting industries are more relevant for understanding clusters than entire regions. Factor inputs are important at the cluster level, but our focus will be on specialized inputs (e.g., the presence of bio-science research centers) particularly useful for the cluster, rather than general inputs (e.g., quality of K-12 education). We also look at government policy and cluster-specific institutions for collaboration.

To better understand how these factors lead to innovation, we analyze the biotechnology/pharmaceutical and communications clusters in San Diego. These two clusters are both good performers and hence offer lessons for other clusters and regions. They are not representative of all clusters in San Diego.

THE BIOTECHNOLOGY/PHARMACEUTICAL CLUSTER IN SAN DIEGO

Nationally, the pharmaceutical/biotechnology cluster is composed of a number of industries that research, manufacture, test, and market a variety of bioscience products and services. The metropolitan area with the highest share of national cluster employment is Boston, with 6.3% of cluster employment. Added together, the metro areas of New York and New Jersey would create the largest region. Other important biotech/pharma centers are present in Los Angeles, Chicago, and Washington, DC.

The biotechnology/pharmaceutical cluster in San Diego is a leading national center of R&D. The cluster has grown rapidly both in terms of employment — adding more than 8,000 jobs from 1988 to 1997 — and in terms of patent output — it had the fastest growth rate of patent registration out of the 20 largest U.S. clusters. The main features of the cluster's composition are the many small companies that tend to focus on one or two drug development targets, as well as the numerous research institutions such as the University of California at San Diego, the Salk Institute, and the Scripps Research Institute, which have strong international reputations in bio-science.

Our assessment of the innovative capacity of the San Diego cluster shows the vital importance of having quality factor inputs, and in particular human capital, for developing a biotech/pharma cluster. Government and private sector efforts attracted a mass of bio-science research institutes, which have produced high-quality research and training. Formal and informal linkages between these institutions and local firms have ensured that technology and human resources are transferred to commercial enterprises. Other factors and elements of the diamond — physical infrastructure, supply of risk capital, local demand, the context for firm strategy and rivalry, and related and supporting industries — have not been sources of competitive advantage for the cluster, but neither have they prevented its successful development.

Development of San Diego's Biotechnology/Pharmaceutical Cluster

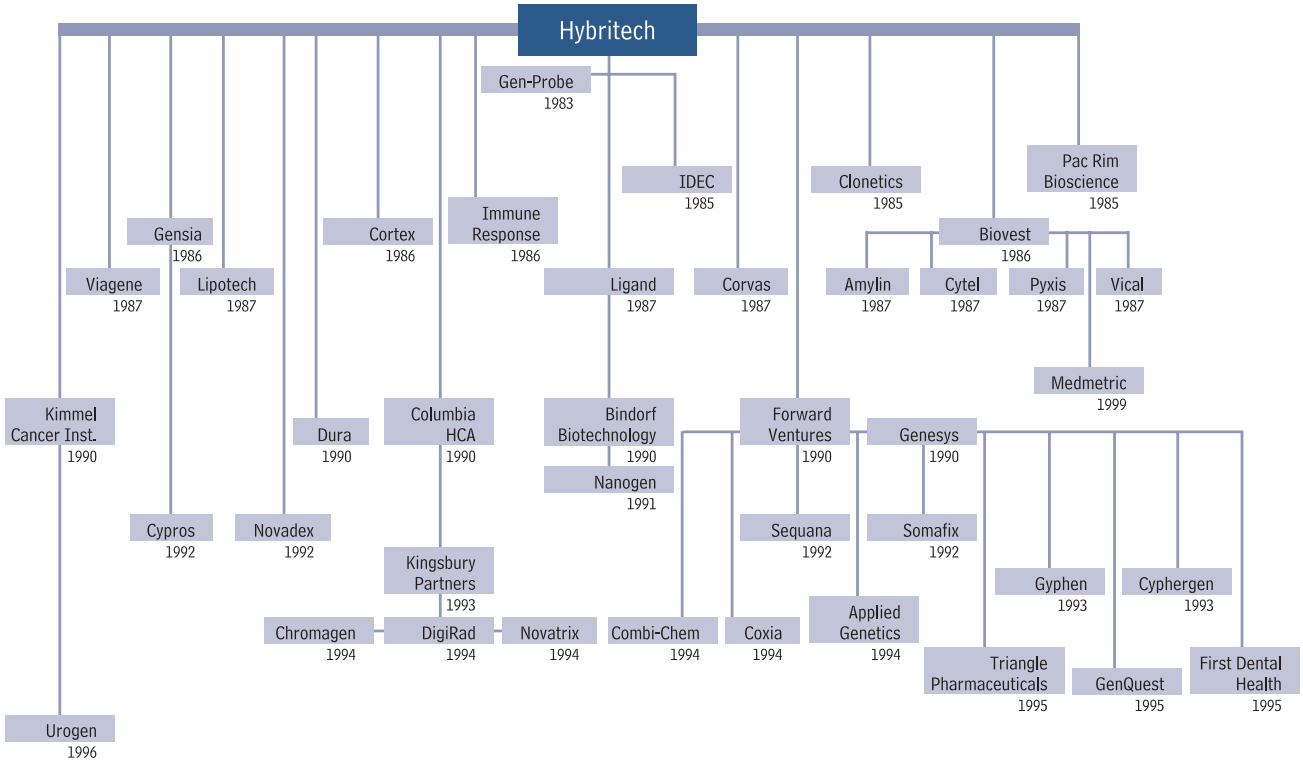
As was discussed above, San Diego's bio/pharma cluster traces its roots to mid-century, when local leaders established the Scripps Research Institute, the Salk Institute, and UCSD.[46] Although the mere presence of these research centers was an important asset, the type of people recruited to run them and the way in which they were run were equally important. The Scripps Institute hired Frank Dixon, an immunologist from the University of Pittsburgh, who worked to develop new fields of study at Scripps. Scripps also required its researchers to raise their own funds, which encouraged innovation and brought more R&D funding into the region, and the Institute consistently partnered with businesses (e.g., Dow Chemicals donated their site), which encouraged more technology transfer to industry.[47] The Salk Institute does not seek corporate sponsorships but is active in licensing its discoveries. About a quarter of Salk's researchers are involved with companies, and the Institute has recently taken equity in several companies. At UCSD, Chancellor Roger Revelle set out to establish the university as a world-class research center focused on physics and medicine, instead of emphasizing engineering, as had been the vision of many of the local defense executives. Later, Chancellor Richard Atkinson, a former professor at Stanford, drew on the Stanford model of university-business collaboration, and encouraged more entrepreneurship among the faculty.

An important event in the development of the cluster came with the founding of Hybritech in 1978 by UCSD scientists Ivor Royston and Howard Birndorf. Hybritech became the first nationally successful biotechnology firm based in San Diego. It also became the training ground for a large number of scientists and managers who would later form more than 50 biotechnology or pharmaceutical firms in the region. Within two years of Hybritech's sale to Eli Lilly in 1986, alumni of the company founded at least eight new firms.

46 The discussion of the history of the biotechnology/pharmaceutical cluster draws heavily from a draft report Pat Windham has developed for the UC system based on our San Diego region interviews.

47 Interview with David Gollaher (former Vice President of the Scripps Clinic and Research Foundation), November 30, 1999, San Diego.

Exhibit 31. Companies Spun out of Hybritech



Source: CONNECT, University of California, San Diego

CASE STUDY OF HYBRITECH

Ivor Royston and Howard Birndorf were two entrepreneurial faculty members attracted to UCSD and the "frontier" of San Diego. In 1978, they formed Hybritech, a firm focused on the development of a prostate specific antigen. The company enjoyed almost immediate success and became the region's first successful home-grown biotechnology firm. In 1986, it was sold to Eli Lilly for $400 million.

The success of Hybritech was important to San Diego's developing biotechnology and pharmaceutical cluster for at least three reasons:

- It demonstrated to the local business and financial community that the industry was viable.
- It was an incubator for entrepreneurial biotechnology managers.
- Its sale provided significant capital to employees eager to start new ventures.

David Hale, CEO of Women's Health and an early employee of Hybritech, explains that the success of Hybritech created an attitude in the firm that "this science could change the world, that the technology we created could actually make great contributions to health care." This positive attitude began to spread from the company to the broader biotechnology community, and later to the general San Diego business community.

While at Hybritech, many young scientists learned how to manage, because they were given great responsibility. Tina Nova, an early employee of Hybritech, explains that because of limited resources, "all employees were being asked to work on every stage of a commercialization project, we were forced to learn at a rapid pace."[48] William Rastetter, CEO of Idec, adds that the Hybritech success "gave life scientists the courage and wisdom to take risks." [49]

Hale, Nova, and Rastetter are among those who have participated with the spin-offs from Hybritech. After Lilly acquired Hybritech, most of the key people left, and many of those started their own firms. Given the poorly developed venture market in San Diego at the time, the capital for the new firms came primarily from the buyout.

The formation of UCSD CONNECT in 1985 was the next important event in the development of the cluster. CONNECT brought VC money into the region, offered business advice and mentoring, connected new businesses with experienced managers, and institutionalized a culture of entrepreneurship within the university. Numerous interviewees credit CONNECT with greatly aiding start-up companies, and in particular with the personal contribution of the late Bill Otterson, CONNECT's former director.

Sometime in the 1980s, the San Diego biotech/pharma cluster reached a critical mass such that growth no longer depended on outside sources. New research centers, like the Burnham Institute and the La Jolla Institute for Allergies and Immunology, had been established and were eager to work with private sector entrepreneurs. The different types of research institutions — ranging from a large public university, to small private centers focused on basic research, to commercially oriented institutes — provided businesses with a range of technologies and partnering opportunities. Several interviewees argue that the close proximity of research centers and firms on the Torrey Pines Mesa encouraged collaboration and growth.

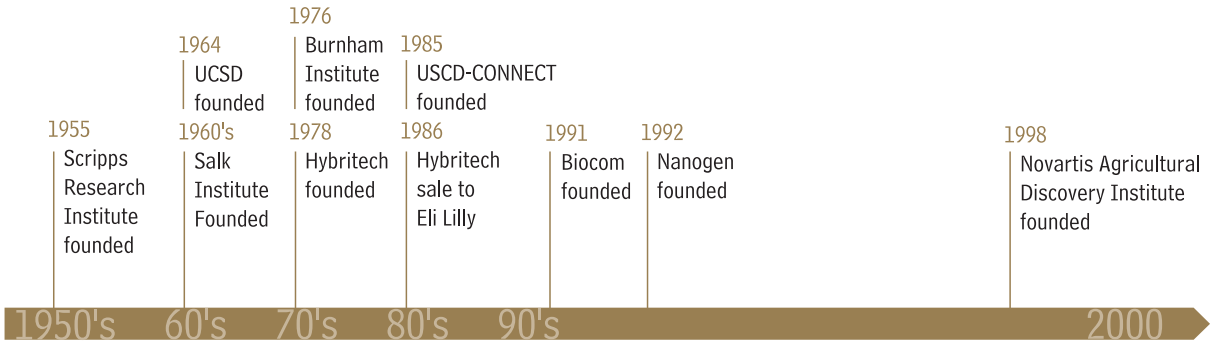
Exhibit 32. Building the San Diego Pharmaceutical / Biotechnology Cluster

Historical Obstacles	Important Enablers	Key Events
■ Little historical tradition as leading in region in bio-sciences	■ Good quality of life	■ Salk decision to locate in the region
■ Initial hesitancy by universities to public-private partnerships	■ Attracting world-class academic research centers	■ Formation of UCSD (and its ambitious research agenda)
■ Lack of venture capital	■ Government R&D funding	■ Success of Hybritech (and sale to Lilly)
■ Lack of local specialized support	■ Success of entrepreneurial firms	
	■ Formation of institution for collaboration	
	■ Culture of cooperation	

Source: Clusters of Innovation Initiative Regional Survey and Interviews

[48] Interview with Tim Nova, December 8, 1999, San Diego.
[49] Interview with William Rastetter, December 6, 1999, San Diego.

Exhibit 33. San Diego Pharmaceutical / Biotechnology Cluster Timeline



Source: Clusters of Innovation Initiative Regional Survey and Interviews

Recent Economic Performance

Employment. In 1997, the San Diego MSA had 27,299 biotechnology and pharmaceutical workers, making it the nation's ninth largest MSA with 2.5% of the nation's biotech/pharmaceutical employment.[50] As measured by location quotient, the San Diego cluster was the fourth most concentrated of the 20 largest clusters in the United States.[51] From 1988 to 1997, San Diego's biotechnology and pharmaceutical cluster had an annual growth rate of 3.9%, fifth fastest among the 20 largest U.S. MSAs.

[50] Cluster Mapping Project Institute for Strategy and Competitiveness, Harvard Business School.

51 Location quotient is a widespread measure of concentration. The formula is a region's share of employment in a cluster, divided by that region's share of total national employment. For example the biotech/pharmaceuticals cluster in San Diego has 2.5% of the nation's biotech pharma workers, whereas San Diego has .86% of the nation's total workers; 2.5% / .86% = 2.9

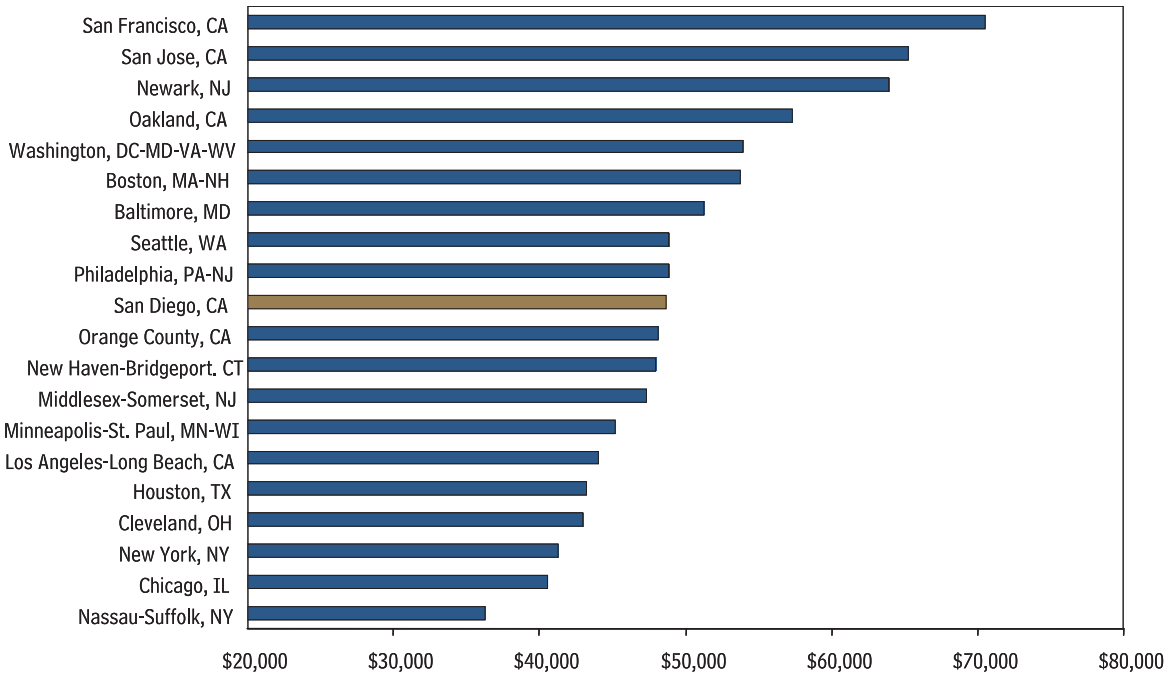
Exhibit 34. Top 20 MSAs for Biotechnology / Pharmaceutical Employment, 1997

Metropolitan Area	Total Employment 1997	Average Annual Employment Growth 1988-1997 (%)	Employment Location Quotient 1997	Share of National Cluster Employment 1997
Boston-Worcester-Lawrence, MA	67,964	1.73	2.36	6.3
Chicago, IL	57,930	-0.53	1.55	5.4
Los Angeles-Long Beach, CA	37,992	-1.71	1.03	3.5
Washington, DC-MD-VA-WV	35,730	5.35	1.75	3.3
Newark, NJ	30,676	1.75	3.42	2.8
Philadelphia, PA-NJ	30,059	-2.77	1.41	2.8
San Jose, CA	29,185	5.80	3.19	2.7
Minneapolis-St.Paul, MN-WI	27,679	5.88	1.81	2.6
San Diego, CA	27,299	3.88	2.93	2.5
New York, NY	26,225	-0.29	0.73	2.4
Orange County, CA	22,766	0.34	1.83	2.1
Nassau-Suffolk, NY	22,486	-1.73	2.18	2.1
New Haven-Bridgeport, CT	22,021	0.32	2.88	2.0
Middlesex-Sommerset-Hunterdon, NJ	19,875	-0.44	3.47	1.8
Oakland, CA	16,957	1.34	1.93	1.6
Baltimore, MD	16,032	1.09	1.60	1.5
Seattle-Bellevue-Everett, WA	14,878	4.51	1.29	1.4
San Francisco, CA	14,442	3.65	1.51	1.3
Houston, TX	12,521	3.50	0.73	1.2
Cleveland-Lorain-Elyria, OH	12,495	1.20	1.19	1.2

Note: Employment includes all employment from noncommercial research and commercial physical research organizations. In San Diego a substantial percentage of these employees are in biotech/pharma.
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

Wages. In 1997, the average wage in the San Diego biotech/pharma cluster was $48,700, roughly 7% above the national average for the cluster. Between 1988 and 1997, San Diego's average wage increased at an average annual rate of 5.3%, versus 4.7% annually. Exhibit 35 reports average wages in the 20 largest U.S. clusters.

Exhibit 35. 1997 Average Wages in 20 Largest Biotechnology/Pharmaceuticals MSAs



Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

Productivity. The employment-weighted average productivity index number of San Diego's biotech/pharmaceutical cluster is 90.5, or 9.5% below the national average. According to our data, four industries in the cluster are more productive than the national average, and seven are less.[52] The youth of the cluster contributes to this low productivity index; there are many firms with drugs in phase 2 and phase 3 clinical trials. These companies have many employees engaged in research but generate little revenue, which depresses their productivity measure.

[52] Data are not available for all industries in San Diego's cluster. This assessment is based on data on 11 out of the 20 industries in the biotech/pharma cluster.

Patents. In 1997, the San Diego biotech/pharmaceutical cluster registered 360 patents, or 13.17 patents per 1,000 employees. This per capita patent registration was tenth highest out of the 20 largest clusters in the United States. Over the 1988 to 1997 period, patenting grew at an average annual rate of 19.5%. The next fastest grower among the 20 clusters was Seattle with 16.9%.

The biotech/pharma cluster in San Diego does well in terms of cited patents as well. It had 13 cited patents per 1000 employees, which was roughly 18% above the national average for the cluster. Thirty-eight percent of San Diego's biotech/pharma patents registered from 1993 to 1997 were cited in 1998. Data limitations preclude measuring growth in cited patents.

Exhibit 36. Total Patents and Patent Growth of the 10 Largest Biotech/Pharma MSAs

Metropolitan Area	Share of National Cluster 1997	Total Employment 1997	CAGR of Employment 1988-1997	Total Patents 1997	CAGR of Patents 1988-1997
Boston-Worcester-Lawrence, MA	6.3	67,964	1.73%	995	14%
Chicago, IL	5.4	57,930	-0.53%	449	6%
Los Angeles-Long Beach, CA	3.5	37,992	-1.71%	278	7%
Washington, DC-MD-VA-WV	3.3	35,730	5.35%	344	14%
Newark, NJ	2.8	30,676	1.75%	353	4%
Philadelphia, PA-NJ	2.8	30,059	-2.77%	671	9%
San Jose, CA	2.7	29,185	5.80%	449	11%
Minneapolis-St. Paul, MN-WI	2.6	27,679	5.88%	342	11%
San Diego, CA	2.5	27,299	3.88%	360	19%
New York, NY	2.4	26,225	-0.29%	368	5%

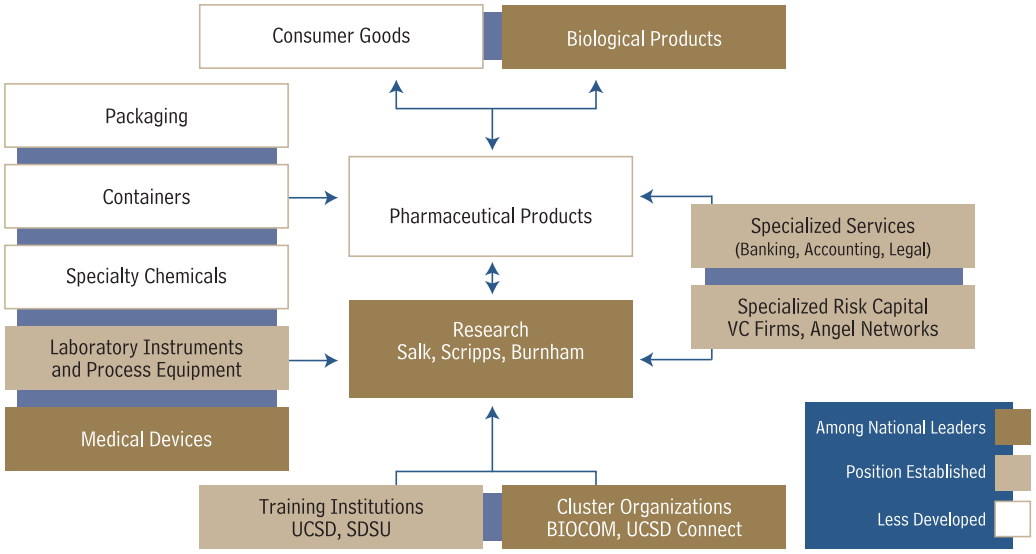
Note: Commercial Physical Research and Noncommercial Research Employment is included in this data
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

Venture Capital Funding and IPOs. According to PricewaterhouseCooper's Money Tree, San Diego's biotech firms received $421 million in VC funding from 1995 to 1999. This was 9.9% of the national total, well above San Diego's 2.5% of national cluster employment. According to Joe Panetta, the executive director of BIOCOM, the region's biotechnology industry association, San Diego biotechnology firms had four IPOs in 1999.[53] BIOCOM's calculations showed that a majority of San Diego-based public biotechnology firms saw their valuations at least double in that year.

[53] Interview with Joe Panetta, December 17, 1999, San Diego.

DESCRIPTION OF THE REGIONAL BIOTECHNOLOGY/PHARMACEUTICAL CLUSTER

Exhibit 37. San Diego Biotechnology / Pharmaceutical Cluster



Source: Clusters of Innovation Initiative Regional Survey, Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School and Interviews

Exhibit 37 depicts the San Diego pharmaceutical/biotechnology cluster. The boxes to the right (specialized services and risk capital) and below (training institutions and cluster organizations) are important components of the cluster, and their relative strength has been assessed using interview and survey data. The other boxes are the industry-based sub-clusters present in the region; their relative strength has been statistically assessed by the CMP.

San Diego's Competitive Position. The San Diego biotechnology/pharmaceutical cluster is focused on research, having one of the strongest critical masses of R&D and clinical testing institutions in the nation. The cluster has particular strengths in agricultural bio-science (Novartis and Dow/Mycogen), cancer therapy (Idec Pharmaceuticals, Immune Response Corporation), and bio-informatics (Nanogen). Many local firms focus on providing intellectual capital and services to larger pharmaceutical companies. In the 1990s, Aguron (Viracept), IDEC (Rituxan), and Ligand (Panretin) received FDA approval for drugs, and some (e.g., Aguron), were acquired by major pharmaceutical firms. Leading international firms like Novartis and Dow have set up major research and development operations in the region.

Exhibit 38 shows the competitive position of sub-clusters and industries in biotech/pharma in San Diego. Research organizations are the greatest area of strength, employing more than 16,000 people,

which constitutes more than 5 percent of the country's employment sub-cluster in research organizations.[54] Biological products are another strong sub-cluster, with a relatively high share of national employment and rapid growth.

The competitive position of other sub-clusters in the region is less impressive. In particular, pharmaceutical products, a core sub-cluster, have a very low share of national employment (although it is growing).

Exhibit 38.
Competitive Position of Industries in San Diego's Biotechnology/Pharmaceutical Cluster

Sub-Cluster	SIC Code	Industry	National Industry Percent Share 1997	Total Employment 1997	CAGR of Total Employment 1988-1997
Overall Cluster			2.48	27,299	3.88%
Pharmaceutical Products*	2833	Medicinals and Botanicals	1.21	323	21%
	2834	Pharmaceutical Preperations	0.13	169	-1%
Containers*	3085	Plastics Bottles			
Consumer Goods*	2844	Toilet Preperations	0.44	288	36%
Biological Products	2836	Biological products except diagnostic	3.46	750	18%
Specialty Chemicals	2843	Surface Active Agents			
	2865	Cyclic Crudes and Intermediates			
	2899	Chemical Preperations, n.e.c	0.45	155	-3%
Packaging	3221	Glass Containters			
	3466	Crowns and Closures			
	2899	Metal Foil and Leaf			
Laboratory Instruments and Process Equipment	3821	Laboratory Apparatus and Furniture	0.76	158	-1%
	3823	Instruments for Process Measurement	1.23	619	-1%
	3826	Analytical Instruments	0.51	175	-10%
	3827	Optical Instruments and Lenses	1.54	360	0%
	3829	Measuring and Controlling Devices, n.e.c	2.78	938	3%
Medical Devices	2835	Diagnostic Substances	4.43	1,965	3%
	3841	Surgical and Medical Instruments	2.57	2,763	6%
	3843	Dental Equipment and Services	1.91	375	-6%
	3844	X-ray Apparatus and Tubes	1.31	175	-15%
	3845	Electromedical Equipment	1.35	561	-12%
	3850	Opthalmic Goods	4.27	1,198	-4%
Research Organizations	6794	Patent Owners and Lessors	2.06	415	15%
	8731	Commercial Physical Research	5.21	10,442	12%
	8733	Noncommercial Research Organizations	6.57	5,430	2%

* Denotes a Unique Industry. Blue shading indicates industry with a higher than expected concentration (i.e. > .86% of the nation's employment)
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

[54] Note that not all of the employment in the research organizations sub-cluster is in the bio-sciences. Although lack of data prevents precise measure of the number of bio-science researchers, most of San Diego's research organizations are bioscience focused.

Cluster Innovative Capacity

Our analysis indicates a strong innovation environment based on federal government investment in R&D, quality universities and research centers, effective institutions for linking noncommercial research organizations with business, and entrepreneurial research institutions and firms.

Specialized Research. Specialized bio-science research centers are a key strength of the cluster. Ninety-five percent of survey respondents stated that specialized facilities for research are readily available to their firm, and 82% reported that these institutions frequently transfer knowledge. Exhibit 39 lists the main research institutes in the metro area.

Exhibit 39. Major Biomedical Research Institutes in the San Diego Region

Institution	Focus
The Scripps Research Institute 1955	■ Basic biomedical research (multiple areas)
The Salk Institute for Biological Studies 1960	■ Basic biomedical research ■ Molecular Biology / Genetics ■ Neurosciences
UC San Diego School of Medicine and its various research centers 1964	■ Basic and applied biomedical and medical device research (multiple areas including pharmacology
The Burnham Institute 1976	■ Basic Research in Cancer
The La Jolla Institute for Allergies and Immunology 1988	■ Molecular and Cellular immunology ■ Allergic Diseases
The Sydney Kimmel Cancer Center 1990	■ Basic Cancer Research and Treatments
The Neurosciences Institute 1992	■ Neurosciences

Source: Interviews, organization websites

Specialized Training and Talent Base. UCSD, San Diego State University, local private universities, and the region's community colleges offer a variety of general courses and specialized programs at the undergraduate, graduate, and continuing education levels. One example is the SDSU Center for Bio/Pharmaceutical and Biodevice Development, which recently launched its first program, a Master of Science in Regulatory Affairs. Interviewees report satisfaction with local training and talent. Tim Rink, CEO of Aurora Biosciences, offers a representative comment, "Though we do not outsource research to UCSD, we continue to support student interns from UCSD, and recognize that the human capital from that institution has infused our labs with talented, excited, and fearless researchers."[55] Two-thirds of the executives surveyed felt that the region provided an ample supply of scientists, and nearly 60% said the pool of skilled workers was sufficient for their growth needs.[56]

55
56 Interview with Tim Rink, December 6, 1999, San Diego.
Clusters of Innovation Initiative Regional Survey.

Sophistication of Regional Demand. San Diego biotechnology and pharmaceutical executives expressed neutral to slightly positive views about the level and sophistication of interaction with their local customer base. Although some interviewees noted that having a medical school at UCSD stimulates business, most discounted its importance in that regard. Nearly 60% of respondents reported that their regional customers were sophisticated and demanding, but they did not feel that this demand provided them with a competitive advantage. Most respondents were neutral or negative (31% for each) about the frequency with which customer feedback led to product improvements, and a comparable number wanted more frequent feedback.[57]

Related and Supporting Industries. There are a number of firms in San Diego that provide lab and testing equipment, conduct drug testing, and do small contract manufacturing of trial drugs. Most survey respondents (71%) stated that these firms provided high-quality goods and services. Fifty-five percent reported that specialized suppliers were frequently available in the region, and 36% said they frequently had to go outside the region to source materials, components, and services. Forty-eight percent stated that specialized suppliers frequently helped them in the innovation process.[58] Each of these ratings was more positive than the average across all regions surveyed.

San Diego has firms in the legal, venture capital, banking, accounting, and real estate services with specialties in technology-related industries. While the quantity and experience of these firms do not match that in Silicon Valley or New York, most of the biotechnology entrepreneurs stated that they could find business services in the region. All agreed that the situation is much stronger than it was in the 1980s. Duane Roth of Alliance Pharmaceutical was among the most bullish on the present business support structure, stating, "there are no services lacking for biotechnology firms in San Diego. Finding suppliers and service providers is not a problem."[59]

Government. Many of the issues regarding government action that were discussed above in the Regional Assessment apply to the biotech/pharmaceutical cluster as well. Government actions have had a positive impact on the cluster through federal R&D funding, state founding and funding of UCSD, local government's zoning of Torrey Pines, and land grants to institutions like Salk. Lack of local action on improving air transport facilities will likely have a significant and negative impact on the cluster.

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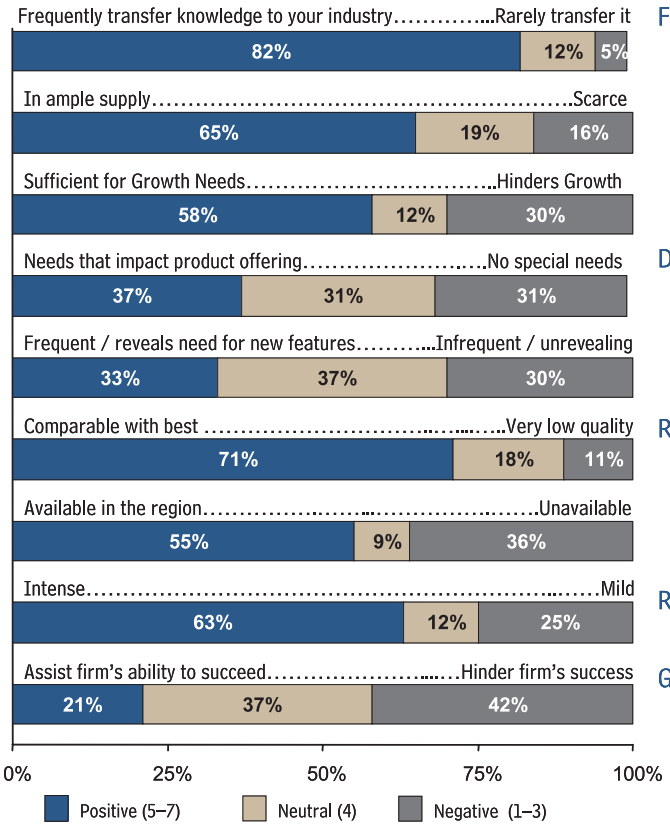
[57] Clusters of Innovation Initiative Regional Survey.
[58] Specialized inputs would include products like chemicals, lab equipment, and biomedical instruments.
[59] Interview with Duane Roth December 6, 1999.

Exhibit 40. Select Survey Results from the San Diego Biotech / Pharmaceutical Cluster



Factors Inputs

- The institutions in your region that perform basic research . . .
- Qualified scientists and engineers in your region are . . .
- The available pool of skilled workers in your region . . .

Demand Conditions

- Regional customers for your business's products / services have . . .
- Feedback from regional customers to improve your business's products / services is . . .

Related and Supporting Industries

- Regional specialized suppliers of your business's materials, components, machinery, and services are . . .
- Specialized suppliers of your business's materials, components, machinery, and services are mostly . . .

Rivalry

- Regional competition in your industry is . . .

Government

- State and regional government regulations affecting your business . .

Source: Clusters of Innovation Initiative Regional Survey

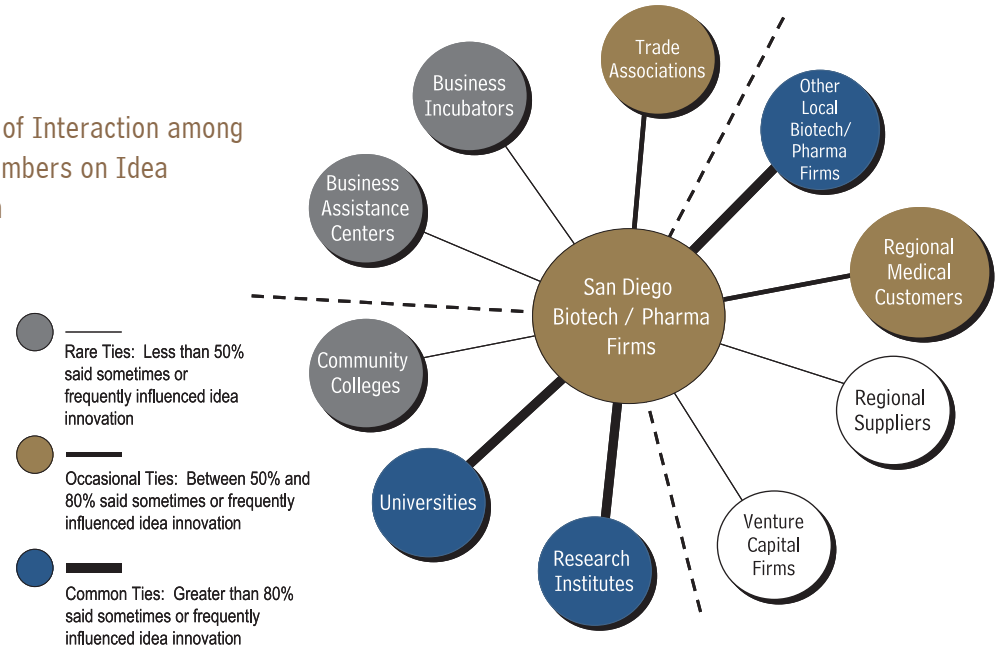
Institutions for Collaboration. Like San Diego as a whole, the business environment of the biotech/pharmaceutical cluster was marked by a lack of business expertise and capital in the 1970s and 1980s. When Dr. Royston and Mr. Birndorf started Hybritech, they were unable to rely on local talent or local money. UCSD CONNECT changed this. Interviewees consistently cite CONNECT as important to the cluster's success, not only because it links firms to research and talent inside the university, but also because it gave firms access to business knowledge and venture capitalists. Seventy-six percent of survey respondents report that CONNECT was helpful to entrepreneurial firms, and 59% said it was helpful to established firms. CONNECT has been especially helpful for the biotech/pharma cluster, and any weakening of its effectiveness would disproportionately affect this cluster.

The cluster also faced a complicated regulatory environment and inattentive local government in the 1970s and 1980s. Interviewees report that BIOCOM has been effective in helping with regulatory and legislative issues and community educational outreach. According to Duane Roth, CEO of Alliance Pharmaceutical, BIOCOM has been very successful in working with local government to secure water availability for the industry and promoting the region as a biotechnology hub.[60] Seventy-four percent of the biotechnology executives we surveyed stated their industry associations were effective at advocating public policies.[61] These approval ratings are substantially higher than average for all regions surveyed.

[60] Interview with Duane Roth, December 6, 1999.
[61] Clusters of Innovation Initiative Regional Survey.

We also asked survey respondents how frequently they interacted with other members of the cluster at the idea generation, product development, and commercialization stages of the innovation process. Results indicate that firms partner with other institutions most often at the idea generation stage, less at the development stage, and least at commercialization. The one exception is interaction with regional customers, with which firms interact most often at the commercialization stage. Exhibit 41 summarizes survey findings of interaction on idea generation. According to our survey, biotech/pharma executives are somewhat concerned about insufficient interaction with their local customers; 46% state that improving feedback from sophisticated local customers is a future threat if not addressed. This was the third greatest concern behind the cost of doing business and the quality of transportation.

Exhibit 41.
Frequency of Interaction among Cluster Members on Idea Generation



CONCLUSION

San Diego's biotechnology/pharmaceutical cluster provides a number of useful lessons for other regions seeking to develop their own cluster and substantiates several propositions of the diamond framework. First, conscious efforts were instrumental in launching the cluster, the most important being the attracting of numerous research institutes, the recruitment of successful scientists from other regions, and the formation of UCSD CONNECT to facilitate knowledge transfer and concentrate business know-how. Second, building the cluster required sustained commitment; bioscience research centers were established by 1960, but the cluster did not take off until the late 1980s. Third, high-quality specialized inputs — and in particular human assets — were vital for growing the biotech/pharma cluster in San Diego. Fourth, geographic proximity — in this case clustering on the Torrey Pines Mesa — facilitated the flow of information and ideas. Fifth, public and private collaboration were important for building the cluster, as is demonstrated by the important role of noncommercial research centers, UCSD, and the collaborative institutions that help link them to industry. Sixth, a diversity of related non-commercial institutions helped the cluster grow by offering companies a variety of models for collaboration. Seventh, Hybritech, and in particular the spin-offs encouraged by the sale to Eli Lilly, was critical to the formation of the biotech/pharma cluster in San Diego.

THE COMMUNICATIONS CLUSTER IN SAN DIEGO

Nationally, the communications cluster is composed of industries that design, manufacture, and sell communications devices and services, as well as research institutions that focus on basic research and product testing. The cluster includes suppliers of specialized inputs, such as electronic resistors, connectors, and optical components. Related industries in the cluster include many information technology industries, such as prepackaged software and computer storage devices.[62] Some industries that provide related equipment such as analytical instruments and measuring and controlling devices are also included. Finally, in each region various related industry organizations, educational institutions, and government agencies play important roles. The communications cluster is broadly distributed nationally. The area with the highest share of national cluster employment is in the San Jose metropolitan area, which has 7.2% of national communications employment. Other important metropolitan areas include Boston, Los Angeles, Chicago, and Dallas-Fort Worth.

In San Diego, the communications cluster ranks fourth in total employment, with approximately 53,400 workers in 1997. Its performance in terms of employment, wages, and patent registration is above average for the nation, and comparable to other leading communications clusters around the country. The San Diego cluster grew in response to the military's demand for communications technology, and with the help of military electronics and communications research. It is still composed of many defense contractors, though they have refocused on commercial applications. Anchored by QUALCOMM, San Diego has become a world leading center in wireless telephony. In recent years, major international companies, such as Ericsson and Motorola, have set up research and development operations in the region, and scores of start-up firms have emerged to exploit new developments in wireless technology.

Our assessment of cluster innovative capacity finds that specialized factor inputs (e.g., R&D funding primarily from the military, a local university, entrepreneurial professors) and the sophisticated local demand of the military were critical to cluster development. Indeed, these elements of the diamond were powerful enough to overcome obstacles to the cluster's development, including the fact that much defense related technology was classified, and that UCSD initially emphasized bio-science over engineering.[63] The local related and supporting industries and the context for firm rivalry and strategy have been neither advantages nor disadvantages. While the region's skilled workforce continues to attract firms, strong labor demand is outpacing regional supply.

Development of San Diego's Communications Cluster

Since World War II, San Diego has been a center for the development of communications technology. Initially, the region focused on missile and aerospace applications. From the 1950s to the 1970s, most of that technology was classified and not transferred to civilian applications. Electronics and communication expertise grew up in the region as major defense contractors like TRW and General Dynamics helped the Department of Defense tackle critical needs in ship-to-shore communications, satellite technology, and portable communications devices.

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62 As explained in the methodology section, Tier 2 industries are significantly correlated with the cluster but more correlated with another cluster.

63 Only in the last decade have concerted efforts been made to foster the cluster: an Engineering School was founded, and Irwin and Joan Jacobs made a generous endowment gift; the Center for Wireless Communications was established, as was Cal IT2; an industry association—the Telecom Council—was formed.

Linkabit, a defense contractor, was formed in 1968 by Irwin Jacobs while still a professor at UCSD. Seeking to spend more time on business issues, Jacobs resigned his academic post in 1972, and joined co-founder Andrew Viterbi to focus entirely on the company. During the 1970s, Linkabit became highly successful, due in large part to its cultivation of young, ambitious managers. In 1980, Linkabit was among the first of the San Diego firms to win a major commercial contract, a satellite communications system for the SBC consortia. In the same year it was acquired by M/A-Com, a large East Coast defense contractor. Spin-offs from Linkabit began as early as 1982.

In the early 1980s, San Diego was not well known nationally as a major center for communications technology. Many of the new firms still focused primarily on defense contracts. There was no major engineering school in the region, no civilian research centers, nor any nationally recognized firms focused on commercial applications.

Exhibit 42. Building the San Diego Communications Cluster, 1940s to 1990s

Historical Obstacles	Important Enablers	Key Events
Lack of Local Venture Capital	Government Defense Funding	Establishment of General Atomics
Lack of Specialized Support Services	Navy Demand for Wireless Communications	Success of Qualcomm's New Cellular Technology
Lack of Specialized Management Expertise	Good Quality of Life	Federal Defense Downsizing
	Long Established Aerospace and Engineering Firms	
	Development of an Entrepreneurial Company into an "Anchor Firm"	

Source: Clusters of Innovation Initiative Regional Survey and Interviews

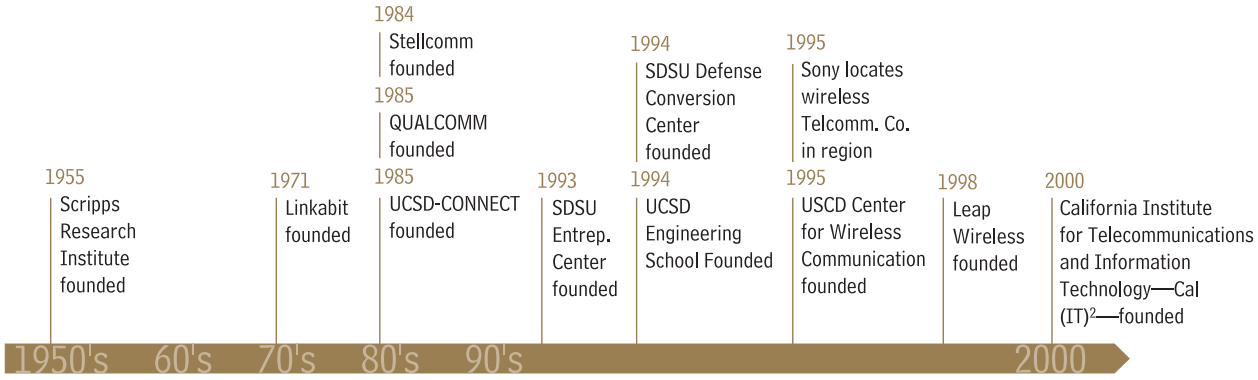
By the late 1980s, however, the cluster began to take off. In 1989, QUALCOMM, a Linkabit spin-off led by Jacobs and Viterbi, developed an important new technology for cellular communications—code division multiple access (CDMA). The new technology led to a highly successful IPO. QUALCOMM put San Diego on the international communications map, motivating other regional entrepreneurs, and attracting capital from outside the region.

The budding commercial communications industry was a beneficiary of the massive defense cuts in the early 1990s. Electronics engineers who had been laid off by defense contractors joined new firms. With help from the federal defense conversion program and impetus from market forces, some defense firms converted primarily to civilian work. Job training programs specifically focused on communications technologies were implemented at various local schools.

In 1992, UCSD expanded its engineering school, complementing the programs already in place at San Diego State. By this time, UCSD CONNECT's efforts to attract venture capital to the region and to link UCSD resources with the business community were producing positive results. In 1995, UCSD founded the Center for Wireless Communications, which works closely with industry in order to generate research and training suited to commercial needs. In 2000, the California Institute for Telecommunications and Information Technology (Cal (IT)^2)—a partnership between UCSD and UC Irvine—was founded with a mission to promote industry-academic research aimed "at enabling anywhere/anytime access to the internet."[64]

San Diego is now the national center for wireless communications.[65] Nokia has made San Diego its center for CDMA research and plans to double its size to 1200 in the county by 2002. Ericsson and Motorola both recently entered San Diego and both have plans to hire more engineers and focus research on wireless technology.[66] The region is now well established as having a major national communications cluster with a particularly strong presence in wireless and internet communications technology.

Exhibit 43. San Diego Communications Cluster Timeline



Source: Interviews, organization websites

Recent Economic Performance

Employment. In 1997, there were 53,400 employees in the San Diego communications cluster. This was 1.9% of total national employment in communications and made the San Diego MSA the fifth most concentrated cluster out of the 20 largest MSAs in communications in the United States.[67] The region's 1% annual growth rate since 1988 was eleventh fastest among the 20 largest clusters.

Average Wages. In 1997, the San Diego's average wage of $50,100 ranked it twelfth among the 20 largest national communications regions. Wages grew at an average of 6.2% annually from 1988 to 1997, a growth level slightly above that of other leading communications clusters.

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64 http://www.calit2.net/

65 One wireless company, Littlefeet, a maker of power stations for cellular networks, worked in Silicon Valley for two months before deciding they had to close shop and move to San Diego to make the company succeed (Mike Drummand, "Telecom troika: Ericsson, Motorola and Nokia Are Lured to San Diego, the Industry's Hotbed," San Diego *Union-Tribune*, April 2, 2000).

66 Ibid.

67 San Diego's employment location quotient of 2.2 made it the sixth most concentrated of the twenty largest communications cluster metro areas.

Exhibit 44. Top 20 Regions for Communications Employment, 1997

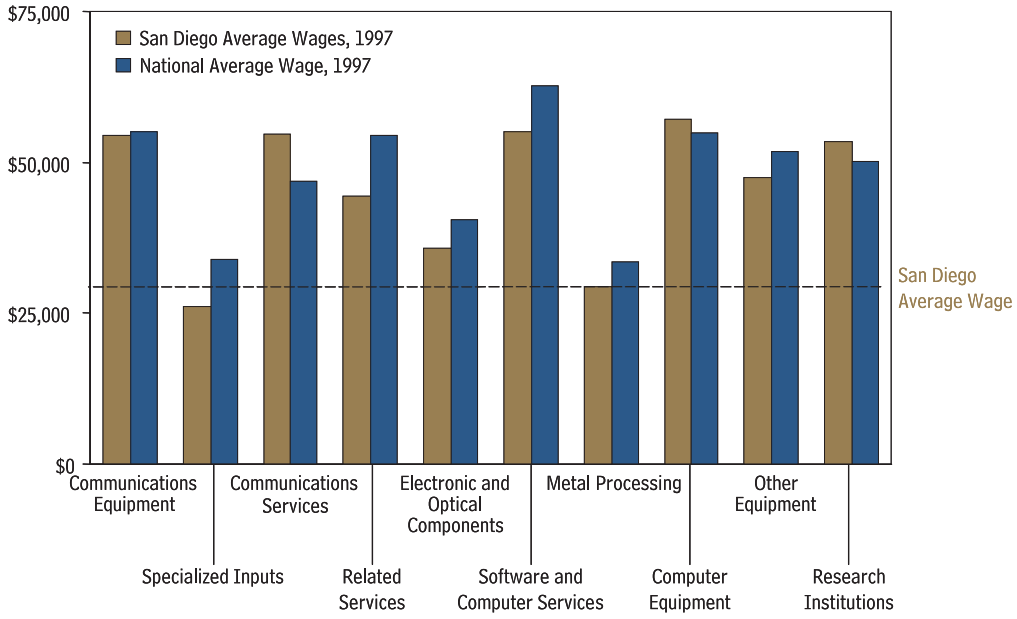
Metropolitan Area	Total Employment 1997	Average Annual Employment Growth 1988-1997 (%)	Employment Location Quotient 1997	Share of National Cluster Employment 1997
San Jose, CA	203,965	-0.1	8.5	7.2
Boston, MA-NH	181,602	-1.1	2.4	6.4
Chicago, IL	138,220	1.9	1.4	4.9
Los Angeles-Long Beach, CA	114,527	-4.2	1.2	4.1
Washington, DC-MD-VA	102,610	4.4	1.9	3.6
Dallas, TX	88,159	1.6	2.0	3.1
Orange County, CA	72,408	-3.8	2.2	2.6
San Diego, CA	53,396	1.0	2.2	1.9
Phoenix-Mesa, AZ	52,729	0.9	1.6	1.9
Austin-San Marcos, TX	52,708	11.2	4.3	1.9
Seattle-Bellevue-Everett, WA	52,526	3.3	1.7	1.9
Minneapolis-St. Paul, MN-WI	52,021	0.1	1.3	1.8
Raleigh-Durham-Chapel Hill, NC	46,608	3.5	3.3	1.7
Philadelphia, PA-NJ	45,987	-2.9	0.8	1.6
Portland-Vancouver, OR-WA	42,949	6.4	2.0	1.5
New York, NY	42,880	-0.8	0.5	1.5
Oakland, CA	40,339	5.9	1.8	1.4
San Francisco, CA	40,063	7.4	1.6	1.4
Atlanta, GA	39,367	5.1	0.8	1.4
Nassau-Suffolk, NY	38,502	-4.9	1.4	1.4

Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

When compared to average wages in communications nationwide, San Diego pays about 5% more. A few high-employment sub-clusters are responsible for raising the regional average wage above national averages: communications services, computer equipment, and research institutions (see Exhibit 45).[68]

[68] Due to data suppression, we have data on 10 of the 14 communications sub-clusters.

Exhibit 45. San Diego Communications Cluster Sub-Cluster Average Wages



Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

Productivity. The employment weighted average index of the San Diego communications cluster is 106.1. Eight industries within the cluster are more productive than the national average, while 11 are less.[69] Low productivity in commercial physical research institutions depresses this average, while higher productivity in noncommercial research raises it. Much of the research in these two industries is not related to communications. Without them, the weighted productivity index is 111.8.

Patents. In 1997, San Diego communications firms and institutions registered 363 patents, representing 1.8% of total U.S. communications cluster patents. This is slightly lower than we would expect since San Diego employs 1.9% of the country's communications workers. Out of the 20 largest communications regions, San Diego ranks tenth in patents per employee, with 6.8 per 1000 employees. The top regions in 1997 in patents per employee were the San Francisco and Oakland metro areas, with rankings of 14.7 and 13.4 respectively.

San Diego's 12.4% annual growth rate in patents since 1988 was eighth fastest among top 20 regions. The large number of communication firm start-ups based on new technology, the recent expansion of Nokia and Ericsson, and the establishment of Motorola's San Diego Product Realization Center suggest that this positive innovation trend will continue.

[69] Data are not available on all industries in the cluster. This assessment is based on data from 19 industries out of the total of 39 industries in the communications cluster.

Exhibit 46. Total Patents and Patent Growth of the 10 Largest Communications MSAs

Metropolitan Area	Share of National Cluster 1997	Total Employment 1997	CAGR of Employment 1988-1997	Total Patents 1997	CAGR of Patents 1988-1997
San Jose, CA	7.2	203,965	-0.15%	2086	16%
Boston-Worcester-Lawrence, MA	6.4	181,602	-1.05%	1098	6%
Chicago, IL	4.9	138,220	1.94%	775	6%
Los Angeles-Long Beach, CA	4.1	114,527	-4.21%	513	4%
Washington, DC-MD-VA-WV	3.6	102,610	4.42%	405	11%
Dallas, TX	3.1	88,159	1.58%	739	16%
Orange County, CA	2.6	72,408	-3.79%	302	7%
San Diego, CA	1.9	53,396	1.00%	363	12%
Phoenix-Mesa, AZ	1.9	52,729	0.86%	366	9%
Austin-San Marcos, TX	1.9	52,708	-11.18%	662	19%

Note: Tier 2 Industries
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

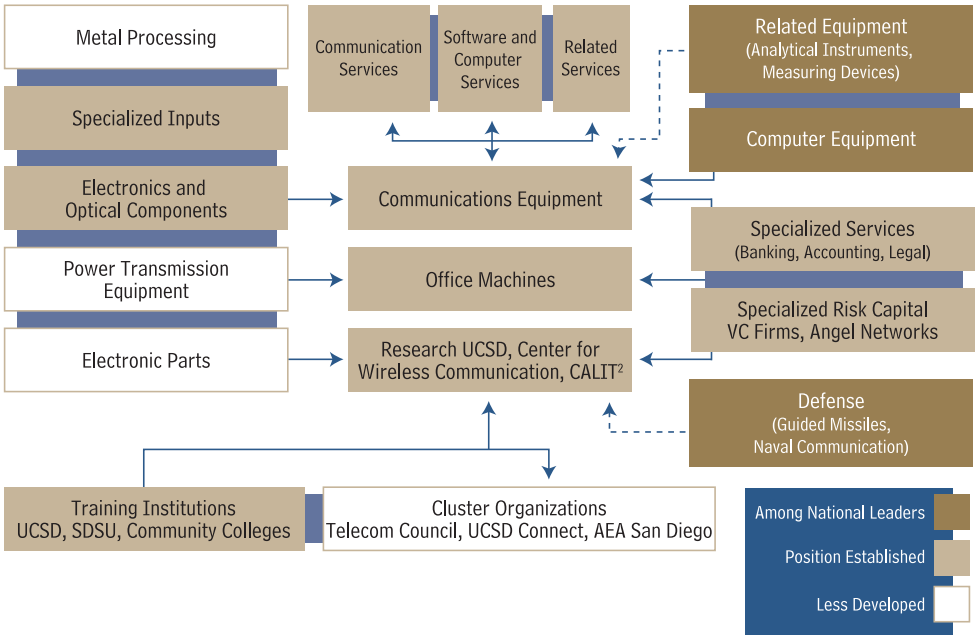
Investments/VC Funding. According to PricewaterhouseCoopers Money Tree database, San Diego regional communications firms raised $326 million in venture capital funds from 1995 to 1999, or 3.0% of the national total over this period.[70]

In 1999, AirFiber, a wireless networking technology firm, received $37.5 million, and four telecom companies, Optical Micro-Machines Inc, PacketVideo, Nuera Communications Inc., and Ensemble Communications Inc. all received funding in excess of $20 million.[71] In the first three quarters of 2000, wireless communications firms continued to top the list of San Diego's firms receiving venture capital. In just the third quarter of 2000, Ensemble Communications secured $63.8 million, Silicon Wave received $57 million, and Novatel Wireless raised 33.9 million.[72]

[70] PWC Money Tree Database.
[71] PWC Money Tree Database.
[72] Bruce V. Bigelow, San Diego *Union Tribune*. "Local Firms Still Raking in Venture Capital, " November 14, 2000. (internet edition).

DESCRIPTION OF THE REGIONAL COMMUNICATIONS CLUSTER

Exhibit 47. The San Diego Communications Cluster



Source: Clusters of Innovation Initiative Regional Survey, Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School and Interviews

The San Diego communications cluster is shown in Exhibit 47. Five boxes (Specialized Services, Specialized Risk Capital, Training Institutions, Cluster Organizations, and Defense) represent related organizations and institutions that are important components of the San Diego communications cluster; they are assessed qualitatively through interviews and surveys. The remaining boxes are the industry-based sub-clusters present in the region, and their relative strength has been statistically assessed through the CMP data set.

The San Diego communications cluster includes leading firms in electronics, satellite technology, and wireless communication devices as well as some communications software developers. Large employers include QUALCOMM; Kyocera, a cell phone manufacturer; and Viasat, a satellite communication firm. Fast growing small firms include Leap Wireless, a wireless network provider; and Nuera Communications, a leading provider of voice-over-internet communications solutions. San Diego communications firms typically maintain their corporate offices, research operations, and product development facilities in San Diego. Some, like Kyocera and Denso Wireless, also manufacture in the region.

Exhibit 48. San Diego Communications Cluster Industries

Sub-Cluster	SIC Code	Industry	National Industry Percent Share 1997	Total Employment 1997	CAGR of Total Employment 1988-1997
Overall Cluster			1.87	53,396	
Communications Equipment*	3661	Telephone and telegraph apparatus	1.09	1,109	3%
	3663	Radio and TV communications equipment	1.42	2,088	2%
	3669	Communications equipment, n.e.c.	1.61	411	24%
Specialized Inputs*	3357	Nonferrous wiredrawing and insulating	0.25	175	37%
	3629	Electrical industrial apparatus, n.e.c.	0.95	175	-8%
	3671	Electron tubes	0.05	10	-38%
	3676	Electron resistors			
	3677	Electronic connectors	2.21	784	10%
Related Equipment*	3579	Office machines, n.e.c.	0.93	175	0%
Communications Services	4820	Telegraph and other communications	0.72	22	-21%
	4890	Communication services, n.e.c.	1.53	524	27%
Related Services	7377	Computer rental and leasing	0.40	39	1%
	7379	Computer related services, n.e.c.	0.96	1,913	23%
Electronic and Optical Components	3644	Noncurrent-carrying wiring devices			
	3672	Printed circuit boards	2.76	2,068	5%
	3674	Semiconductors and related devices	0.66	1,273	-10%
	3677	Electronic coils and transformers	0.24	47	-19%
	3679	Electronic components, n.e.c.	1.56	3,311	0%
	3695	Magnetic and optical recording media	0.70	175	-7%
	3827	Optical instruments and lenses	1.54	360	0%
Software and Computer Services	7372	Prepackaged software	1.64	4,229	21%
	7375	Information retrieval services	2.69	824	67%
	7376	Computer facilities management	0.55	326	2%
Metal Processing	3325	Steel foundries, n.e.c.			
	3351	Copper rolling and drawing			
	3356	Nonferrous rolling and drawing, n.e.c.	0.05	10	0%
	3365	Aluminum foundries	0.18	64	1%
	3463	Nonferrous forgings	0.60	60	0%
	3469	Metal stampings, n.e.c.	0.38	375	0%
Cabinets	2517	Wood TV and radio cabinets			
Power Transmission Equipment	3568	Power transmission equipment, n.e.c.			
Electronic Parts	3643	Current-carrying wiring devices	0.13	60	-8%
	3691	Storage batteries			
Computer Equipment	3571	Electronic computers	0.80	800	-12%
	3572	Computer storage devices	0.59	229	-18%
	3577	Computer peripheral equipment, n.e.c.	7.12	6,364	8%
Related Equipment	3651	Household audio and video equipment	1.09	375	-16%
	3761	Guided missiles and space equipment	0.67	75	-28%
	3810	Search and navigation equipment	2.52	4,513	-3%
	3825	Instruments to measure electricity	3.51	2,168	5%
	3826	Analytical instruments	0.51	175	10%
	3829	Measuring and controlling devices, n.e.c.	2.78	938	3%
Research Institutions	8731	Commercial physical research	5.21	10,442	12%
	8733	Noncommercial research organizations	6.57	5,430	2%

* Denotes unique industry
Note: Tier 2 Industries
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

Exhibit 48 shows the relative size and growth of the sub-clusters within San Diego. The communications equipment, computer equipment, and software and computer services sub-clusters are all relatively strong and have been growing steadily. Communications services has posted exceptional growth, with its national sub-cluster share increasing rapidly to 1.5 percent in 1997. Research institutions in communications also have seen growth, although the high share displayed on the chart is misleading because of the presence of non-communications-related research institutions in the total.[73] Only three sub-clusters in communications in San Diego had national shares less than the regional average of 0.86 percent in 1997, showing a generally strong and complete cluster.

At an industry level, the drivers of the sub-cluster performance become evident (see Exhibit 48). The radio and TV communication equipment industry (driven by QUALCOMM) posted strong employment gains, as did communication and computer-related services and software. However, some industries have been declining rapidly despite the strong overall performance of the cluster. For example, semiconductors and related devices, and electronic computer manufacturing, both significant in size, lost nearly half of their 1988 employment.

Cluster Innovative Capacity

Our analysis indicates a strong innovation environment has emerged, based primarily on defense demand and investments, the labor force, and university-business linkages.

Specialized Research Centers. While nearly 80% of survey respondents reported ready access to local research centers, only 42% expressed satisfaction with the level of knowledge transfer to their industry; 36% said these research institutions rarely transferred knowledge.[74] The concern about the lack of technology transfer is somewhat mitigated by fact that most firms in the industry prefer to rely on proprietary research and development operations. Still, it seems that local firms could benefit more from the technology being developed at local institutions.

In recent years, San Diego has improved its academic and training infrastructure to support specialized research in communications-related fields. UCSD expanded its engineering school in 1998 and now conducts research in a broader array of electronics fields. The university is also home to the Supercomputer Center, and in 1995 UCSD and a consortium of local industry partners created the Center for Wireless Communications (CWC) to support basic and applied research that benefits the local cluster.

Specialized Educational Institutions and Talent Pool. San Diego is home to a comparatively large number of skilled workers in the communications cluster. According to the Bureau of Labor Statistics, in 1998 there were 5,400 electrical or electronic engineers and more than 6,500 electrical or electronic engineering technicians in the region, well above the national average.[75] As Motorola vice president Ron Garriques reported, "Given that we are a leader in all technologies, we looked at the skill sets in San Diego and decided we had to be there."[76]

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[73] The research institutions subcluster within the communications cluster has significantly overstated employment in this cluster. As previously mentioned a large percentage of the research institutions in San Diego are focused on bio-sciences. The methodology used by the government to assign institutions to SIC codes is not specific enough to allow a specific break-out of communications research center.

[74] Clusters of Innovation Initiative Regional Survey

[75] Bureau of Labor Statistics, Civilian Labor Force Data (Does not include military personnel, which would increase San Diego's talent base relative to most areas).

[76] Mike Drummand, San Diego *Union Tribune*. "Telcom Troika: Ericsson, Motorola, and Nokia are Lured to San Diego, the Industry Hotbed," April 2, 2000 p.1-1.

Nevertheless, most San Diego executives are concerned about future access to employees. Sixty-seven percent of the executives surveyed reported that the supply of scientists and engineers in the region was too scarce to meet their expansion needs, and 56% percent reported that the supply of skilled workers was inadequate.[77] The communications cluster benefited from the defense cuts, and resulting increase in the supply of skilled labor. But this was a one-time boost. Although the engineering school at UCSD produces graduate level engineers, and programs at San Diego State and San Diego City College develop engineers and managers, a recent report by the San Diego Workforce Partnership found that technicians and workers in specialized fields unique to communications generally receive training from private providers.[78] While the report found that there were sufficient training programs available, there did not exist a specified set of training courses for individuals interested in entering the communications field. Many of the executives we interviewed echoed the Workforce Partnership report's call for a more coordinated workforce training system. They also noted the lack of managerial talent, specifically in marketing and sales.

Sophistication of Regional Demand. Although the Navy's presence continues to be an asset boosting local demand, San Diego communications executives expressed only neutral to slightly positive views about the level and sophistication of interaction with their local customer base. Fifty-one percent of survey respondents said that their regional customers spur them to create new products and services. Communication executives expressed a desire to obtain more frequent feedback from their customers about product offerings.[79] All responses were lower than average across the regions we surveyed.

Related and Supporting Industries. San Diego communications executives expressed satisfaction with their access to specialized suppliers, but did not feel regional suppliers provide the cluster firms with a particular competitive advantage. Eighty-eight percent of the respondents reported their regional suppliers of components, materials, and services are comparable with, or better than, the quality of inputs found elsewhere, and 55% said they can source most of their inputs from sources within the region. A substantial minority of 34%, however, reported that they frequently go outside the region for supplies.[80] About 40% of the respondents consider their specialized suppliers as frequent contributors to their innovation efforts, slightly below average across all regions.[81]

Context for Firm Strategy and Rivalry. The San Diego communications cluster exhibits rapid growth of new firms, moderate competitive rivalry, and sporadic collaboration among firms. According to the national mapping database, 1,324 net new establishments were created in the cluster in San Diego from 1988 to 1997. San Diego's ranking against the 20 largest communications regions rose from thirteenth to seventh in terms of its total number of establishments.[82] This strong growth rate is consistent with the findings in a recent report prepared by the San Diego Regional Technology Alliance (SDRTA). The SDRTA report, which focused specifically on wireless communications, found the number of firms dedicated to wireless technology had risen from 40 in 1990 to 160 in 1998.[83]

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77 Clusters of Innovation Initiative Regional Survey.
78 "San Diego's Communications Industry Cluster: A Regional Employment Study," San Diego Workforce Partnership, 2000, p. 13.
79 Clusters of Innovation Initiative Regional Survey.
80 Clusters of Innovation Initiative Regional Survey.
81 Clusters of Innovation Initiative Regional Survey.
82 Cluster Mapping Project Institute for Strategy and Competitiveness, Harvard Business School.
83 Wireless Wonders: Assessing San Diego's Wireless Industry, San Diego Regional Technology Alliance, September 2000, p. 1.

Fifty-one percent of survey respondents described competition in their cluster as intense, while 49% called it moderate to mild; 45% stated there were many firms competing in the industry, whereas 55% claimed there were average to few firms competing locally. Response rates were low relative to other regions for both questions.

Executives in the San Diego communications cluster have mixed views about the amount of firm-level collaboration that exists in the region. There has been a history of legal battles over technology between the major players. Both Motorola and Ericsson have had major patent disputes with QUALCOMM over CDMA technology. In the past two years, QUALCOMM has settled disputes with both parties. A new, more positive attitude toward cooperation seems to be emerging. In response to the settlement with Motorola that allows Motorola to sell CDMA handsets without a royalty, QUALCOMM CEO Irwin Jacobs said that the two firms could now seek "ways of working together to expand the market for CDMA and to deliver increasingly more valuable services for CDMA subscribers."[84]

Government. As noted earlier, government actions have been important contributors to the growth of innovative capacity in the cluster, primarily through federal/military funding of R&D, the Navy's demand for wireless communications technology, and state funding of colleges and universities such as UCSD and SDSU. Communications executives tend to agree with general concerns that local governments have difficulty coordinating to meet region-wide challenges such as improving physical infrastructure.

A series of positive governmental actions — federal, state, and local — most relevant to the communications cluster were the efforts to assist defense firms, and laid-off defense workers, to develop commercial applications for their technology. In 1994, the City of San Diego was awarded $5.8 million from the U.S. Economic Development Administration for defense conversion assistance. Among the initiatives funded were: a technology incubator and training center at San Diego City College, now the Center for Applied Competitive Technology (CACT); an entrepreneurship program through UCSD CONNECT; and a dislocated worker training program at SDSU.[85] With the assistance of these and other programs, many firms were able to survive by diversifying their focus to include private sector markets.[86]

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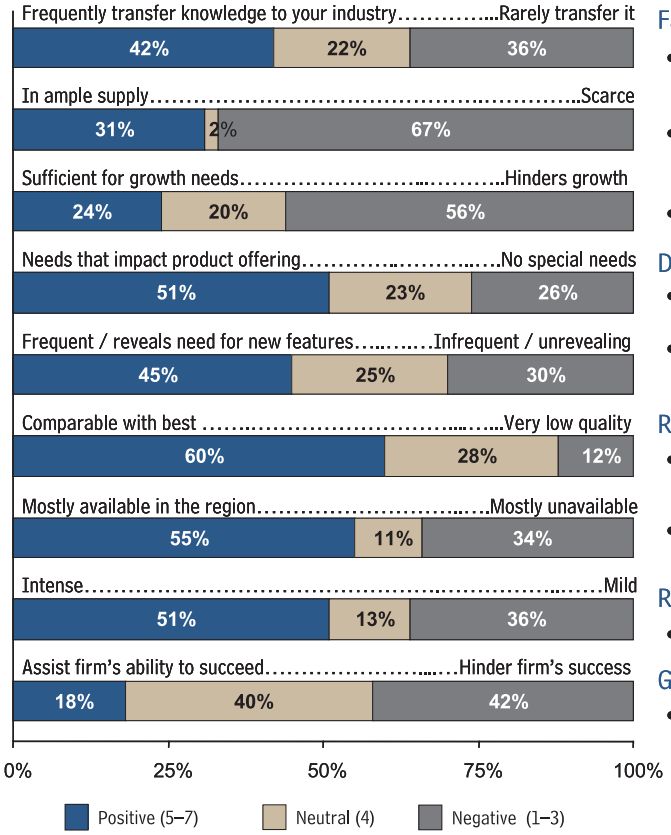
84 Mike Drummand, San Diego *Union Tribune*. "Telcom Troika: Ericsson, Motrorola, and Nokia are Lured to San Diego, the Industry Hotbed," April 2, 2000 p.1-1.

85 Developing High-Technology Communities: San Diego (Office of Advocacy, U.S. Small Business Administration, April, 2000), p. 62.

86 One example is ORINCON Technologies, originally a defense contractor that focused on tracking technologies for submarines. ORINCON relied on Small Business Innovation Research grants from the U.S. Department of Commerce to help design and test new products based on its defense related technologies. Today, ORINCON continues to win Department of Defense contracts, but also has sensor products that are used to detect impending crashes at airports, and small children who are at risk of falling into swimming pools (Developing High-Technology Communities: San Diego (Office of Advocacy, U.S. Small Business Administration, April, 2000), p. 84).

Exhibit 49. Select Survey Results from the San Diego Communications Cluster



Factors Inputs

- The institutions in your region that perform basic research . . .
- Qualified scientists and engineers in your region are . . .
- The available pool of skilled workers in your region is . . .

Demand Conditions

- Regional customers for your business's products / services have . . .
- Feedback from regional customers to improve your business's products / services is . . .

Related and Supporting Industries

- Regional specialized suppliers of your business's materials, components, machinery, and services are . . .
- Specialized suppliers of your business's materials, components, machinery, and services are . . .

Rivalry

- Regional competition in your industry is . . .

Government

- State and regional government regulations affecting your business . . .

Source: Clusters of Innovation Initiative Regional Survey

Institutions for Collaboration. The communications cluster in San Diego took off partly in response to the cuts in defense spending. The scarce knowledge and resources needed at this time were information and expertise on how to compete for civilian — as opposed to military — customers. As with most companies in San Diego, many communications firms turned to UCSD CONNECT for this knowledge. The communications executives we interviewed most frequently cited CONNECT as the most helpful institution for collaboration.

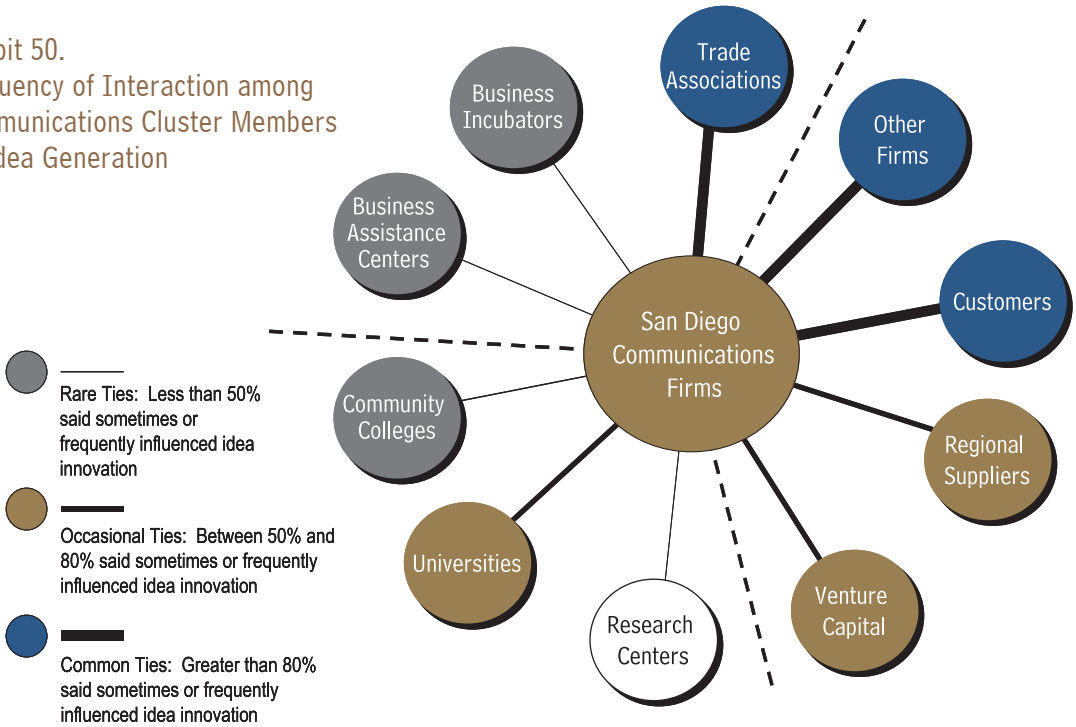
Helpful though CONNECT was, it did not focus exclusively on the communications cluster. Throughout most of the 1990s, there was no San Diego-based institution for collaboration devoted to helping communications and related firms. The American Electronics Association (AEA) was commended by many interviewees, but it is a national, not a regional, institution. The SDRTA focuses on downtown San Diego. In 1998, the San Diego Telecom Council was founded to fill this need. Its mission is to promote San Diego as a center of communications innovation, help communications firms access new information and resources (e.g., skilled labor and university based technologies), and lobby government. It is too early to assess the Telecom Council's effectiveness.

The lack of established institutions for collaboration is apparent in our survey results. Forty-seven percent of communications executives said their cluster associations were effective versus 74% for biotech/pharma executives. Forty-two percent of communications respondents said universities frequently transfer knowledge, versus 82% of biotech/pharma respondents.

We also asked survey respondent how frequently they interacted with other members of the cluster at the idea generation, product development, and commercialization stages of the innovation process. In San Diego, communication firms are more likely to use partners to generate new ideas than they are to jointly develop or commercialize an idea. Fewer than 25% of firms say that they frequently used outside partners in their idea development or commercialization processes, while 36% say they commonly look outside their firm for new ideas.

When communications firms use outside partners, they are more customer-facing than biotech/pharma companies. More than 80% of the firms sampled say that their regional customers and industry associations were sometimes or frequently helpful. More then 90% of the firms said that other cluster firms were sometimes or frequently helpful in the process of idea generation. Some of this stems from direct collaboration with firms that take place on a bilateral basis or through joint research centers like the CWC. Additionally, many firms mentioned that they are spurred to develop new product ideas by the competitive advances or technological developments of other cluster firms, most specifically QUALCOMM. As Ake Persson, the local Ericsson manager, comments about the San Diego operation, "we have only one mission in life: to develop the CDMA business."[87]

Exhibit 50.
Frequency of Interaction among Communications Cluster Members on Idea Generation



Source: Clusters of Innovation Initiative Regional Survey

87 Mike Drummand, San Diego *Union Tribune*. "Telcom Troika: Ericsson, Motrorola, and Nokia are Lured to San Diego, the Industry Hotbed," April 2, 2000 p.1.

CONCLUSION

San Diego's communications cluster is an instructive case for several reasons. First, it shows that high-quality specialized inputs, in the form of R&D funding and talented scientists and engineers, were instrumental to the development of the cluster. Second, it was also important to connect the people doing basic research with the people who knew how to start up companies. For years, much defense-related technology was classified, and academics were discouraged from collaborating with industry. After the Cold War ended, and academic restrictions were relaxed, the cluster began to grow more rapidly. Third, anchor firms like Linkabit and QUALCOMM were important for generating spin-offs that established the cluster itself. Fourth, sophisticated local demand by the U.S. Navy for wireless communications and other technologies helped build the cluster. Fifth, the cluster's development demonstrates the need for sustained commitment; local leaders began attracting military installations to the region in 1908, but did not see major economic benefits from this until World War Two. The communications cluster did not emerge strongly out of the military firms until the 1980s. Sixth, the formal and informal institutions for collaboration among the members of the cluster are still developing and the cluster's performance reflects this fact. The communications cluster is less well connected with basic researchers at UCSD than is the biotech/pharma cluster, and the communications cluster does not perform as well in terms of innovation output measures.

5 SUSTAINING COMPETITIVE ADVANTAGE: LESSONS, CHALLENGES, AND OPPORTUNITIES

ACCOMPLISHMENTS

San Diego has accomplished a great deal in economic development over the last century. Beginning in 1908, local government attracted a military presence that not only spawned numerous business clusters (e.g., aerospace engines, aerospace vehicles and defense, analytical instruments, information technology, communications, power generation, transportation and logistics, and sporting and leather goods), but also preserved the region's quality of life, itself an important economic asset. In the 1950s, government and industry attracted bio-science research centers that, again, preserved the quality of life and grew several clusters (e.g., biotech/pharma, medical devices, education and knowledge creation). The leaders of these research centers encouraged resident scientists and engineers to collaborate with industry, and despite initial resistance, were ultimately successful. Finally, a desire to integrate the university more actively into the economy produced UCSD CONNECT, a model university-business institution for collaboration that facilitated the flow of research and ideas from the university and brought scarce local business resources to university-based entrepreneurs.

The result is strong regional innovative capacity, as well as strong innovative capacity for numerous clusters. Exhibit 51 summarizes the innovative capacity of the region, the biotechnology/pharmaceutical cluster, and the communications cluster.

Lessons

San Diego's accomplishments, and the process by which San Diegans have encouraged the development of their economy, offer numerous lessons for how other regions can emulate its success:

- **Innovation.** The San Diego economy has produced considerable innovation output over the last decade, and this has led to rapid growth; San Diego's most innovative clusters — like sporting and leather goods and medical devices — are among the region's top performers.
- **Traded industries.** Traded industries are key drivers of economic performance. The lower than average wages in San Diego are due to the lower than average employment in traded industries; as regional employment in traded industries rises, so too will average wages.
- **Clusters.** Clusters are another key driver of the performance of a regional economy. When the aerospace and defense cluster in San Diego struggled, so too did the regional economy. As clusters such as education and knowledge creation, business services, and sporting and leather goods grew, the regional economy emerged from recession.

Exhibit 51. Summary of the Regional Innovative Capacity

Elements of Regional Innovation Environment	Assets	Challenges
Basic and Specialized Factor Inputs	■ High levels of investment in basic research ■ Many research institutions in a variety of fields ■ High quality of life ■ Good higher education ■ Large number of scientists and engineers in the workforce	■ Public K-12 educational system ■ Little management and marketing expertise ■ Small airport ■ High cost of living ■ Expensive and unreliable utilities
Government Policy	■ High level of federal R&D funding ■ High level of state support for UCSD ■ Streamlined permitting by local government	■ High business and personal tax rates ■ Poor coordination among local political jurisdictions
Quality of Linkages	■ High quality university-based institution for collaboration (UCSD CONNECT) ■ Increased focus on cross cluster and cross-jurisdictional networking ■ Strong informal networks	■ High business and personal tax rates ■ Poor coordination among local political jurisdictions
Attitudes Toward Business	■ Entrepreneurial attitudes in academia	■ Signs of a shift among academics away from interest in working with industry

Source: Clusters of Innovation Initiative Regional Survey, interviews, secondary sources, Monitor analysis

- **Unique assets.** Success was based upon building on existing strengths. The military, the defense companies, and the research institutions were initially attracted to San Diego by natural factors. In the military's case, the harbor and the city's geographic location proved critical, and the City helped by dredging the Bay. For the research institutes, climate and the availability of land were central, and again the City accommodated through zoning and land grants. In both cases, the region's natural endowments were useful to the companies, and also led to a high quality of life which attracted talented people (e.g., Irwin Jacobs' coming to San Diego on sabbatical and staying on).
- **Leadership.** Interviewees consistently mention a handful of individuals whose work contributed greatly to the economic development of San Diego: Irwin Jacobs (QUALCOMM), Richard Atkinson (UCSD), William Otterson (UCSD CONNECT), Ivor Royston (Hybritech), and David Hale (CancerVax). The efforts of a few individuals such as these created regional strengths that enabled many more to succeed.
- **Sustained commitment.** It took 20 years to build a large military presence, and another 20 years to realize significant development of the clusters that grew from the Navy's research agenda. Scripps opened its Research Institute in 1961, but the biotech/pharma cluster did not take off until the late 1980s. In both cases, local leaders had to commit significant resources to assemble a critical mass of facilities and institutions, and then wait many years to witness the economic returns.
- **Institutions for collaboration.** The base assets for the communications and biotech/pharma clusters existed in San Diego by the 1960s, but the clusters did not emerge strongly until the 1980s to

1990s. One reason for the lag was that the metro area lacked people with business experience and risk capital. UCSD CONNECT was founded in 1985; it focused on bridging both of these gaps. Local clusters began to show strength shortly thereafter.

- **Diversity of research institutions.** UCSD, Scripps, Salk, Burnham, the CWC, General Atomics, and organizations such as the Navy's SPAWAR enable companies to choose from a diverse set of models of how research institutions interact with companies in the region.
- **Value of proximity.** Several interviewees mentioned that the close proximity of research institutions on the mesa encouraged innovation. The success of Research Triangle Park in North Carolina points to the same conclusion.
- **Cooperation among local businesses, government, and knowledge centers.** When these groups shared a common agenda and all worked to achieve it, they succeeded in bringing the military, bio-science research centers, UCSD, the supercomputer center, and the engineering school to the region. When they failed to cooperate they lost national competitions to host computer and superconductor research centers.
- **Anchor firms.** A few companies, notably Linkabit and Hybritech, spawned dozens of others. Other regions have recruited major firms to the area, and they too have produced many spin-offs. Large companies inevitably experience mergers, acquisitions, and reorganizations that result in lay offs. When a region offers a high quality of life and an environment that supports start-ups, laid-off talent will begin their own companies rather than leave the area.

The Need for New Directions

San Diego has become a highly competitive and innovative region. Yet competition is dynamic, and to remain competitive, San Diego must be dynamic as well. Our analysis identifies several themes which will be necessary if San Diego is to transition from a young and growing economy to a mature and strongly performing one. We develop these themes further in the Challenges and Opportunities sections that follow.

Jobs to wages. The region has been successful at creating many jobs, as evidenced by the strong rebound from an unemployment rate higher than the nation's average to one lower by the late 1990s. This strategy made sense, particularly in light of the defense cuts of the early 1990s.

It is important to emphasize that this finding is not due to the large military presence in San Diego because military employment is not included in our data. Neither is this finding a result of the large hospitality and tourism cluster, because regional average wages remain at about the national average even when we remove this cluster from our calculations. Furthermore, even in high paying clusters like communications, San Diego wages are at about the national average. The region has jobs; the task now is to raise the average wages.

Basic research to the entire value chain. San Diego leaders have successfully attracted many research institutions to the region. This proved a good way to grow a variety of clusters. Now that these clusters are present, however, strength across the entire value chain needs to be developed. Clusters in the region need more sophisticated and demanding customers, more local suppliers who actively participate in improving goods and services, better specialized institutions providing training and support services, and more local firms vigorously competing with each other.

Noncommercial organizations to companies. The primary locus of innovation in San Diego has been in government and noncommercial research organizations such as SPAWAR, UCSD, Salk, and Scripps. The private sector has participated in innovative activity, but has not been the driving force behind innovation. As the San Diego economy matures, companies need to become more central to the innovation process with noncommercial organizations performing a vital, but supporting, role.

"High-tech" clusters to all clusters. "High-tech" clusters in San Diego such as biotech/pharma and communications are young and growing. They are not, however, the main employers in the region. Clusters such as hospitality and tourism, business services, education and knowledge creation, sporting and leather goods, and transportation and logistics have created the most jobs in the region from 1988 to 1997. The next step in San Diego's economic development is to encourage innovation and upgrading across all clusters.

Regional institutions to cluster institutions. A key to San Diego's economic success was the creation of institutions for collaboration that served the entire region (e.g., UCSD CONNECT, SANDAG, and SDREDC). UCSD CONNECT was especially important for transferring knowledge from the university to companies. As the regional economy matures, strong cluster-specific collaborative institutions will be needed to foster supplier development, specialized training, international marketing, and the like. Some clusters, such as biotech/pharma with BIOCOM, already have good institutions. Many clusters, however, lack an institution for collaboration that is focused on their cluster, or have nascent cluster institutions that are not yet well established. Nurturing cluster-focused institutions represents an important future agenda.

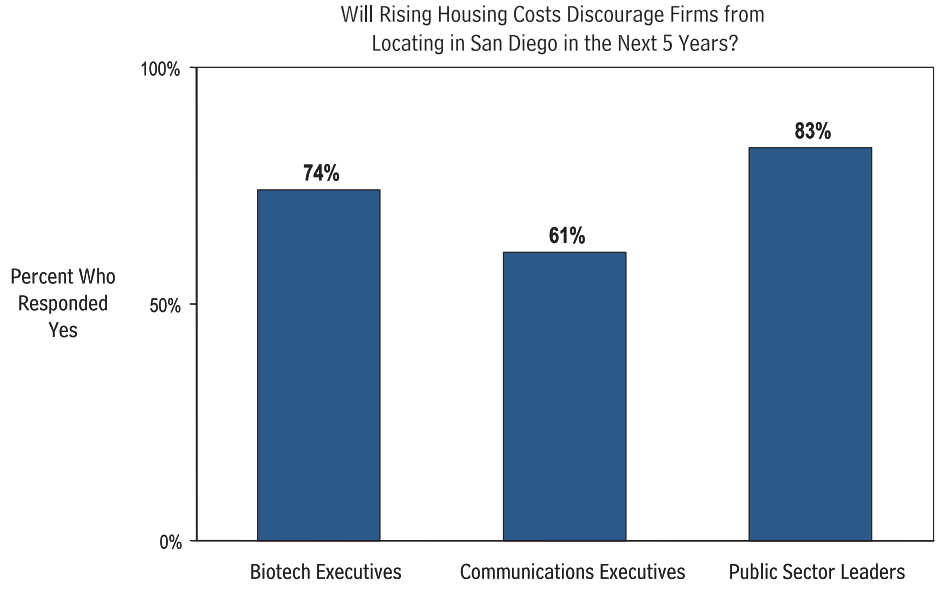
At the same time, San Diego has many collaborative institutions, "too many" according to some. These include institutions to foster regional and even international government coordination, institutions linking universities with industry, institutions linking industry to the military, chambers of commerce and economic development organizations, industry councils, and local chapters of national cluster organizations. The resources are tremendous, but the effectiveness could be improved. To this end, the region would benefit from an overarching institution which would facilitate cooperation among institutions for collaboration and help avoid redundant programs.

Challenges

In moving in these new directions, San Diego faces a variety of challenges. Some have existed for many years, while others are consequences of more recent success. The overall quality of life is under strain. San Diego is no longer a "pleasant smaller town." Explosive growth has placed a burden on much of the region's infrastructure. The consequences of success threaten to undermine several of San Diego's historical assets, and the challenge will be to maintain these assets that have proven so effective in the past. Other challenges have existed for some time, and need to be addressed if San Diego is to develop an economy that competes with the best in the world.

Cost of living. San Diego has a California cost of living but does not have California wages. In 1997, average wages in San Diego were $28,855 versus $32,089 in California. San Diego's cost of living is roughly 25% above the national average, whereas its average wages are 2-5% above the national average. An important consequence of this is that it will make it more difficult for San Diego to successfully compete for talent. Talent has been, and will continue to be, the region's most important asset. The cost of living will not decline in the foreseeable future, and this suggests San Diego's challenge is to boost innovation, which will increase productivity, and which in turn will enable employers to pay higher wages.

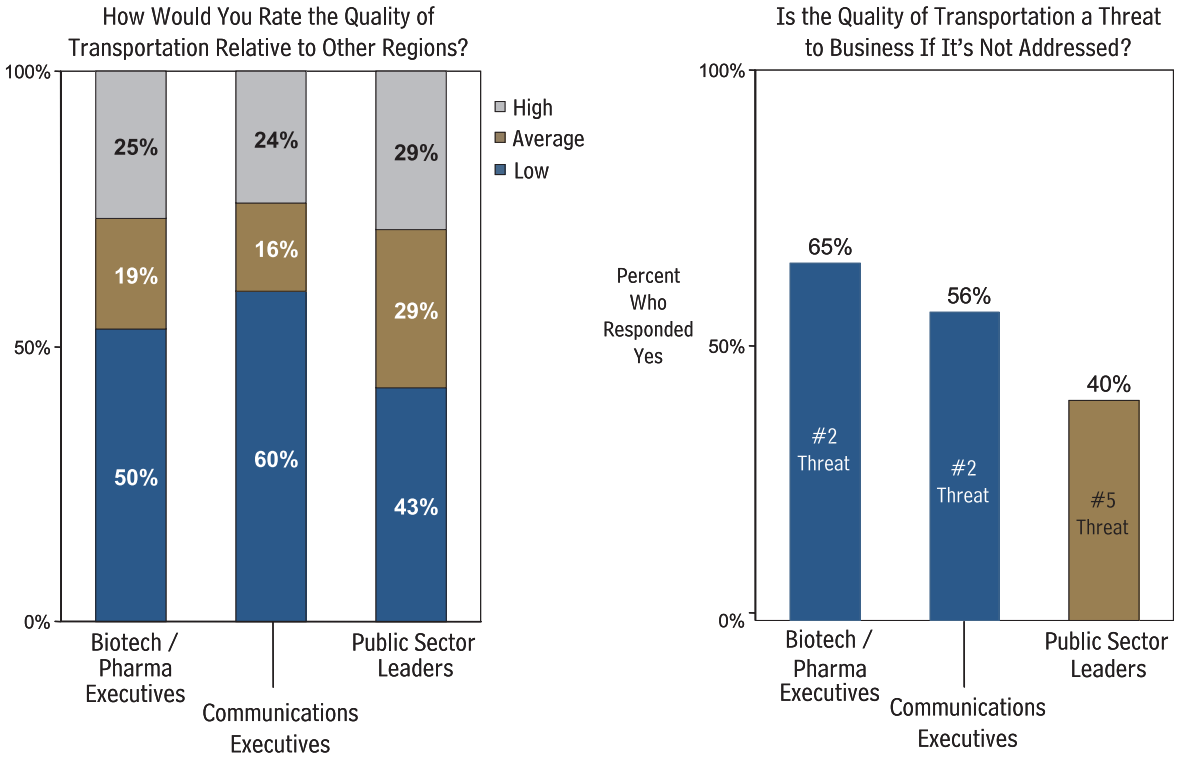
Exhibit 52. Select Survey Results on the Consequences of the Rising Cost of Living



Source: Clusters of Innovation Initiative Regional Survey

Physical infrastructure. San Diego needs to upgrade aspects of its physical infrastructure. Most critical will be increasing air transport capabilities, both passenger and cargo. This issue consistently emerged in both surveys and interviews as a high priority problem. The region outgrew Lindbergh Field years ago and has relied on airports in Los Angeles. Now, however, demand for air transportation throughout Southern California is outpacing supply. This is especially important for many large and fast growing clusters such as transportation and logistics, business services, hospitality and tourism, biotech/pharmaceuti-

Exhibit 53. Select Survey Results on the Quality of the Regional Transportation System



Source: Clusters of Innovation Initiative Regional Survey

cals, communications, and information technology, because these clusters directly depend on efficient air transport to move their products and customers, and because professionals in these clusters need to travel to make frequent face-to-face contact with colleagues and clients around the globe.

San Diego, and California as a whole, must also develop reliable supplies of energy. Power blackouts were occurring with little warning in the month of March; the problem will only get worse in the summer. As one biotech executive put it, "to be successful a company must be able to produce three consecutive runs of product, and the power cannot be shut off during this process." In addition to these two pressing problems, reliable water supplies, greater sewage disposal capacity, and a better system of local roads will likely become issues in the future. Rapid economic and population growth confront San Diego with a host of physical infrastructure issues.

Resolving these infrastructure problems has proven difficult in the past, and yet failure to solve them will result in a significant degradation of business efficiency, as well as the local quality of life, one of San Diego's key assets over the years.

Quality of life. San Diego needs to develop a strategy to **redefine and upgrade** its quality of life. In the past, its climate, beaches, and small-town feel attracted scientists and researchers who were critical to the region's economic success. The climate will not change, but the beaches are more crowded and less accessible, and the city has grown into a sizeable metropolis. Put another way, the danger is that San Diego will look more and more like Los Angeles and Silicon Valley, but without comparable wages or cultural amenities.

As San Diego inevitably loses its small-town feel, it should go beyond refurbishing its reputation for "sunshine dollars." To achieve this, the region should consider broadening the definition of the "quality of life." A number of interviewees mentioned that San Diego is still seen as "culturally disadvantaged" relative to Los Angeles, San Francisco, Boston, and other competitive locales. Opportunities exist, they believe, in further improving the region's theater, symphony, and other arts in order to provide a more robust "intellectual environment" and support the region's attractiveness as a tourist destination.

Human resources. Although San Diego's high-quality human resources have been a key source of success in the past, it is clear that some types of skills will be lacking in the future. Operating in cross-cluster fashion, pioneer defense and research organizations sponsored and attracted related, reinforcing institutions. The most notable of these is, of course, UCSD. The expansion of UCSD — most prominently the School of Engineering but also the Plant Genomics Center, the Ocean Engineering program, the Super Computer Center, the Cancer Center, and the Center for Magnetic Recording Research — has been important to the region's prowess in research and commercialization. This nexus of institutions will in some respects, however, not suffice going forward.

Exhibit 54.
Bio-science Executives' Assessment of Current and Necessary Future Skill Levels

Skills by Major Occupation	Current Skill Level	Skill Level Needed in 2-5 Years	Percent Improvement Needed
Product and Process Development			
1 Knowledge of pre-clinical drug development	3.43	4.14	20.70%
2 Knowledge required to enter international markets	3.60	4.25	18.06%
3 Product strategy for moving technology to market	3.40	4.20	23.53%
Business Administration			
4 Marketing and promotion	3.29	4.33	31.61%
5 Sales / distribution	3.11	4.37	40.51%
6 Organizational development / HRM	3.30	4.25	28.79%
7 General management	3.55	4.32	21.69%
8 Entrepreneurial know-how	3.79	4.42	16.62%

Source: SDSU Survey

Some of the areas of deficit noted in the interviews were digital processing and computer science at UCSD, the lack of an MBA program in the region, the lack of a PhD in biotech, and the lack of a PhD/MBA combination. A 1999 survey by the San Diego Workforce Partnership reached similar

conclusions. Executives of bio-science companies were asked to rate the current skill level of their employees on a scale of 1 to 5 (low to high), and also to anticipate needed skill levels in the next 2-5 years. The greatest skill shortfall was in business administration skills — such as marketing, promotion, sales, distribution, and human resource management — although a wide range of skills emerged as areas of concern (see Exhibit 54).

One implication for the San Diego community might be to return to past practice and lobby for UCSD (or other educational institutions) to expand in these critical areas.[88]

Finally, San Diego needs to continue to upgrade its K-12 education system. Our assessment of the quality of basic education is that San Diego is at, or slightly above, the national average. Average is not good enough for a knowledge-intensive economy like San Diego's. Moreover, if the rising cost of living, changing quality of life, and downsizing of the military make it more difficult to bring outsiders into the region, it will become more important to upgrade the quality of local workers.

Institutions for collaboration. The current capacity of institutions for collaboration will likely prove insufficient for the needs of the future. One reason is that informal networks will tend to become less effective in the future. Informal networks have been a strength in San Diego, but as the economy grows, so too will the number of people and firms that need to collaborate. People will also find it more difficult to meet as they spread out over the county and as traffic congestion worsens; the people who need to collaborate will "bump into each other" less often. Success will tend to make informal connections less effective.

A second reason is apparent from the results of our Clusters of Innovation Initiative Regional Survey. UCSD CONNECT has been an important collaborative institution, but it is the only region-wide institution to receive high ratings in our survey.

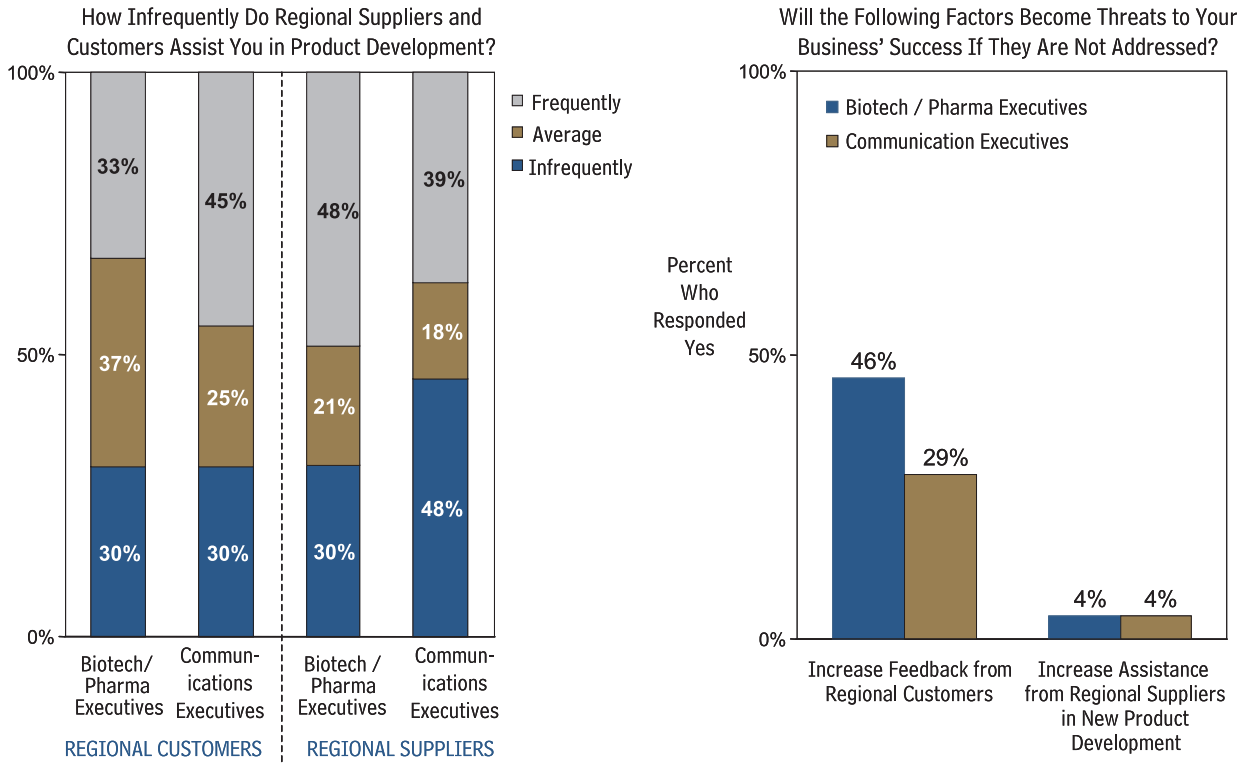
A third reason that is also apparent from the survey and interviews is that technology transfer offices need to improve. San Diego depends on taking basic research from noncommercial research entities like UCSD and putting it to commercial uses. As the economy grows, so too will demand for commercially relevant basic research, and smooth transfer will become increasingly important.

A fourth reason is that the San Diego economy is also shifting from one with many start-up companies to one containing more established companies. CONNECT has focused on serving the needs of start-ups, and a connective institution focusing on established companies would prove useful. UCSD CONNECT recognizes this, and is broadening its mission to include established companies. This change, however, raises the concern that CONNECT will lose focus and be less effective for both start-ups and established companies.

Cluster depth and interaction. Clusters in San Diego need to build strength in all four determinants of innovative capacity: specialized inputs, related and supporting industries, context for firm strategy and rivalry, and demand conditions. Clusters often are strong in some determinants, but not others. For example, the biotech/pharma cluster is very good at transferring knowledge from research institutions to firms, but is weaker at eliciting feedback from local customers and suppliers on how to innovate better.

[88] One interviewee mentioned the possibility of an MIT/Sloan School "satellite program" being delivered in San Diego.

Exhibit 55. Select Survey Results on Cluster Depth and Interaction



Source: Clusters of Innovation Initiative Regional Survey

Our interviews and survey indicate that biotech/pharma executives are unconcerned about this weakness; they argue competitive advantage derives primarily from having access to superior research. This may be true for the time being, but it is a dangerous attitude going forward. Some firms have the advantage of being near quality research institutions such as UCSD whereas other do not. However, in time, virtually all the firms that survive will be near research institutions and so this will cease to be a differentiator. At this point, the presence of sophisticated local demand and numerous suppliers who all help firms innovate will become key advantages. Because it takes time to build these assets, clusters in San Diego should begin doing so now.

Internationalization. Companies in San Diego need to compete more internationally. Although San Diego has high per capita exports and export growth rates, much of this is due to shipments of electronics parts to Mexico for final assembly and export back into the United States. In other words, the good export numbers are not indicative of true internationalization. Exports to the most competitive, most sophisticated markets in the world are an important benchmark of innovation success. Competing in these markets will also impart lessons for how to innovate better.

Government coordination. Solving many of these challenges will require effective government action. Historically, San Diego's government has been effective. In the case of both biotechnology and

telecommunications, an accommodating local government proved critical to capitalizing on attractive natural factors in cluster creation and growth. The city dredged the harbor, gave the land, and zoned the mesa. The question becomes, is local — or regional — government replicating its accommodating stance vis-à-vis new business? The answer would appear to be "no" for several reasons. The San Diego area is no longer as free to offer physical assets to companies and institutions, not least because of their limited physical quantity; there is, for instance, only so much land.

Having said that, with respect to those assets which are available, government receives decidedly mixed reviews, often being seen as neither accommodating nor effective. The mixed reviews are directed at both the substance of government's decisions and the processes by which those decisions are reached: "Regional government is weak and ineffective with regard to the planning and implementation of regional development"; "Local government is weak; the mayor's office is structurally weak"; "There is no consensus (among government institutions) on regional growth issues"; "San Diego's regional government is compared unfavorably to others - the Bay Area's "Joint Venture Silicon Valley" or Los Angeles' "The Zone"; "Government is not business friendly. This makes it very difficult to build physical plants." One interviewee in question opted to buy land and build facilities in another state instead.

While some governmental organizations, notably SDREDC, received at least occasional accolades for their efforts, the general lack of government support and the complexity of multilevel requirements for building and permitting (for example, the state-level California Conservation Commission versus local regulators) generally seem to have obviated the region's historically accommodating stance. For instance, SANDAG is responsible for siting new airport facilities, and it is a committee composed of 19 political jurisdictions; achieving cooperation among them is a challenging task.

Opportunities

In addition to confronting threats to historical assets, San Diego faces opportunities that are underrealized. These include upgrading the broad range of clusters present in the region, better leveraging the presence of the military, the close proximity of Mexico, and the potential for new clusters. Certainly San Diegans are aware of these opportunities, and to some extent exploit them. However, based on our interviews, they receive less attention than they could and should.

Upgrading traditional clusters. San Diego has the opportunity to support and boost innovation across a larger number of clusters. Many regions in the United States have only a few relatively concentrated clusters. San Diego, however, has a large number of clusters already present in the region. These include not only biotech/pharma and communications, but also, hospitality and tourism, transportation and logistics, business services, medical devices, analytical instruments, power generation, aerospace vehicles and defense, education and knowledge creation, printing and publishing, sporting and leather goods, information technology, and more.

Targeting a few clusters for support will boost innovation, productivity, and wages in a few clusters. This risks creating a bifurcated economy where a relatively small number of people enjoy prosperity. San Diego already has a strong presence in a number of clusters that employ many people. The region should leverage these existing assets further.

Better leveraging of the military presence. In many respects, San Diego remains a Navy town, where each aircraft carrier is reportedly worth $1 billion to the region annually. In addition to the direct economic benefit and the potential for sourcing employees from the military, the Navy and the Department of Defense continue to offer strong core federal R&D funding. The SPAWAR budget, now at $1.3 billion annually (of which $800 million is provided by the Navy and $500 million by other organizations, notably DARPA), has been growing at an annualized rate of 10% over the last five years. It is, moreover, focused on promising high-growth technology areas: for example, command and control systems, surveillance/reconnaissance, ocean engineering and environmental monitoring. More than 75% of the SPAWAR budget is outsourced to firms, many of them in San Diego such as SAIC, TRW and Raytheon.[89] A major area of interest for DARPA — an agency with nearly $2 billion to spend on R&D investments — is the links between bio-science and information technology and how this could serve U.S. security.[90] San Diego has several institutions for collaboration that work to link companies with military projects including the San Diego Defense and Space Technology Consortium, and the San Diego branches of the Armed Forces Communications and Electronics Association and the National Defense Industrial Association. Local firms are well positioned to take advantage of opportunities to better develop commercial spin-offs from the development of military technology.

Mexico. San Diego is not thinking hard enough about how to benefit from its proximity to Mexico. Baja California lies 14 miles from San Diego, and the two regions inevitably affect each other. Yet, few of the interviewees discussed opportunities in Mexico. Those that did tended to do so superficially or to reflect on the fact that Mexico's role is not given sufficient weight in local decision-making: "San Diegans don't recognize the importance of their close location to the maquilas"; "There is a lack of a regional partnership involving business, government and universities to create a research zone or innovative region with Mexico; There are "opportunities in training and manufacturing involving Mexico"; "The North is overbuilt; growth must go South"; "For every ten new jobs in Tijuana, there's one new job in San Diego."

There are a number of opportunities which, if seized, would benefit both San Diego and Mexico. One set of opportunities is infrastructure issues. Mexico lies 14 miles from San Diego, shares its environment, and can adversely affect San Diego's quality of life. For example, waste from manufacturing and humans is dumped into the Tijuana River which then flows into the United States before reaching the Pacific at Imperial Beach, CA. Cross-border cooperation will be necessary to solve this and other environmental issues. Mexico also offers more positive opportunities for solving several of San Diego's critical infrastructure needs. San Diego, and southern California more generally, will soon need more air transport capacity. Rodriguez Field in Baja California nearly touches the U.S. border. Adding terminal facilities on the U.S. side and more runways on the Mexican side could prove a relatively simple plan for increasing capacity. Another opportunity is joint energy production. Both Mexico and California need more energy, and siting plants in Mexico is often easier and cheaper than doing so in the United States.

Another set of opportunities is presented by the large manufacturing presence in Baja California. This presence enables San Diego to develop a number of industries and clusters that could otherwise not exist due to the lack of manufacturing in the county. These include engineering and design services, business services, financial services, and transportation and logistics.

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89 Tom Sprague, "Moving at Flank Speed," San Diego *Daily Transcript*, October 19, 2000, 4A.

90 See Focus 2000 on the DARPA website: www.darpa.mil

91 Data for this paragraph is drawn from Alan R. Sweedler, "Energy Issues in the San Diego/Tijuana Region," Briefing paper prepared for San Diego Dialogue's Forum Fronterizo policy luncheon series (November, 1999).

A third set of opportunities is available due to the current and future growth potential of Mexico, and Latin America more generally. There is a large population with moderate to high income, and many counties in the region are poised to grow rapidly over the next 10 to 20 years. San Diego companies are well positioned to seize opportunities for increased trade in hospitality and tourism, higher education, construction services, communications services and equipment, power generation, and health care, to name a few.

New cluster opportunities. There appear to be a number of opportunities for new clusters or subclusters to develop in the region. New clusters often emerge at the intersection of existing clusters. One example is bioinformatics-medicine and engineering. San Diego has strength in biotechnology, communications, information technology, and related high technology areas. Another example of potential arises from San Diego's proximity to the ocean. There is little mention of the specific roles of the Scripps Institute or of UCSD's strong ocean engineering programs and their impact on competitiveness. Third, an opportunity may be present in the intersection of the biotech cluster and the substantial local agribusiness sector. This list is meant to be illustrative, not exhaustive.

Interviewees report that there is something of a tendency for San Diego institutions to operate within "vertical silos" rather than to embrace "horizontal issues." Some of the failure to address horizontal issues may stem from weaknesses in existing collaborative institutions. For example, UCSD gets mixed reviews around technology transfer and flexibility of faculty. Several interviewees described the technology transfer process as slow and cumbersome.

appendix 1
DEFINITION OF MEASUREMENTS

OUTPUT MEASURES

Measure	Definition	Calculation	Source
Employment	Number of persons employed per MSA/cluster	Sum of employment in all counties constituting the Metropolitan Statistical Area (MSA)	County Business Pattern Data on 4-digit Standard Industrial Classification (SIC) industries per county
Wages	Payroll of region/cluster per employed in MSA/cluster	Total payroll dived by total employment per region/cluster; calculated as employment weighted average of wages per county (for region) or industry (for cluster)	County Business Pattern Data on 4-digit SIC industries per county
Productivity	Value of shipment per employee in MSA/cluster	First, NAICS (North American Industry Classification System)-based shipment data is transformed to SIC codes using the bridging methodology provided by the 1997 Economic Census. The weights of each NAICS code assigned to a SIC industry are based on the proportions of total sales/ receipts/shipments each NAICS accounts for that SIC code.[92] However, this transformation does not generate data for all industries defined in the SIC code. Also, some data are suppressed to avoid disclosing individual company data. Second, the value of total industry shipments is divided by total industry employment.	Census Bureau Shipment Data; County Business Pattern Data on 4-digit SIC industries per county

[92] These proportions are calculated at the national level. Any given county, however, will not perfectly mirror the U.S. economy in terms of the proportion of types of firms within a given NAICS code. We calculate a productivity index for 336 4-digit SIC industries in San Diego; 182 of these contain data from fractions of a NAICS industry.

OUTPUT MEASURES (Continued)

Measure	Definition	Calculation	Source
Productivity(cont.)		Of the 720 SIC industries listed for San Diego, information is available for 365 industries. Data on a further 29 industries are suppressed. We can calculate a productivity index for 336 industries in San Diego in 1997.[93]	
Exports	Value of manufacturing and non-manufacturing commodity exports per MSA	Direct use of data.	U.S. Department of Commerce's International Trade Administration data on the two-digit SIC level

INNOVATION MEASURES

Measure	Definition	Calculation	Source
Patents	Number of patents registered per MSA/cluster	Direct use of data for MSAs. For clusters, we need to distribute the aggregate number of regional patents to individual industries	Commerce Department data on patents per MSA
Venture Capital Investments	Value of venture capital investment per MSA/cluster	Direct use of data	Pricewaterhouse-Cooper's Money Tree Database
Fast Growth Firms	Value of venture capital investment per MSA/cluster	Direct use of dataInc. Magazine lists companies by sales growth. "Gazelle" firms are defined by employment growth above 100% over four years	Inc. Magazine Top 500 list of high-growth companies Cognetics "Gazelle" companies' list
Initial Public Offerings	Number of IPOs per MSA	Direct use of data	Hoover's IPO Central.com

[93] These proportions are calculated at the national level. Any given county, however, will not perfectly mirror the U.S. economy in terms of the proportion of types of firms within a given NAICS code. We calculate a productivity index for 336 4-digit SIC industries in San Diego; 182 of these contain data from fractions of a NAICS industry.

COMMON BUSINESS ENVIRONMENT MEASURES

Measure	Definition	Calculation	Source
Basic research	Federal funds for research universities per MSA	Direct use of data	National Science Foundation WebCASPAR Database System
Skills of work-force	Number of employees per skill and MSA	Direct use of data: Number of scientists / engineers, technicians in scientific and engineering fields, managers and professionals, and science and technology graduates in the regional workforce	US Bureau of Labor Statistics, Occupational Employment Statistics
Education	Expenditure and performance per student and MSA	Direct use of data: High school graduation rates, student/teach ratios, average expenditures per student, and SAT scores	California Department of Education, National Center for Education Statistics
Physical infra-structure	Transportation System, Communications System, Utilities	Direct use of data	Texas Transportation Institute Annual Mobility Report, Clusters of Innovation Initiative Regional Survey Data, Secondary Sources
Supply of Risk Capital	Size of local venture capital industry	Direct use of data: Number of local venture capital firms, and total funds management by local venture capital firms	Alternative Assets
Quality of Life		Direct use of data: Cost of housing, and level of traffic congestion	Clusters of Innovation Initiative Regional Survey Data, Secondary Sources

CLUSTER-SPECIFIC BUSINESS ENVIRONMENT MEASURES

Measure	Calculation	Source
Specialized research centers	Direct use of average questionnaire response: How available are local research centers to use by private firms, and how frequently do they transfer technology and knowledge to the private sector?	Clusters of Innovation Initiative Regional Survey, and interviews
Specialized talent base	Direct use of average questionnaire response: Is there a sufficient number of qualified scientists, researchers, technicians, and business managers to sustain and grow companies in the region?	Clusters of Innovation Initiative Regional Survey, and interviews
Specialized training	Direct use of average questionnaire response: Do local institutions supply a sufficient number of qualified scientists, researchers, technicians, and business managers, and will this improve or worsen in the future?	Clusters of Innovation Initiative Regional Survey, and interviews
Sophistication of demand	Direct use of average questionnaire response: Are local customers sophisticated in their demand for new and better products, and do companies receive regular feedback from these customers?	Clusters of Innovation Initiative Regional Survey, and interviews
Intensity of rivalry	Direct use of average questionnaire response: How many local rivals are there in your cluster, and would you characterize competition as more intense or more mild?	Clusters of Innovation Initiative Regional Survey, and interviews
Degree of cooperation	Direct use of average questionnaire response: Do firms share knowledge with each other, and do they consistently contribute to cluster-wide projects and initiatives?	Clusters of Innovation Initiative Regional Survey, and interviews
Related and supporting	Direct use of average questionnaire response: What is the quality of local suppliers and supporting industries, how frequently do firms source from outside the region, and how much feedback to related industries give on improving products and processes?	Clusters of Innovation Initiative Regional Survey, and interviews

appendix 2
RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY

To generate primary quantitative and qualitative data, we have conducted a Clusters of Innovation Initiative Regional Survey and in-depth interviews in the region.

The survey (available on the Council on Competitiveness' website at www.compete.org) was completed by 168 executives at companies and institutions throughout the region. Of the total, 103 were companies from the biotech/pharmaceutical and communications cluster, and 65 were from regional institutions of collaboration and other non-cluster organizations (e.g., venture capital firms, banks).

The in-depth interviews were conducted by our team with 35 individuals in the San Diego region. Of these, 23 were with business executives in the biotech/pharmaceutical and communications cluster, 4 were executives in other clusters, and 12 were with representatives from academic, government, or collaborative institutions.

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY

Measure	Description of Rating Scale	Number of Respondents	Average	High	Neutral	Low
The cost of doing business (specifically, the cost of real estate, wages and salaries, and utilities) is…	**1** *High relative to other regions* **7** *Low relative to other regions*	168	2.36	4.76%	6.55%	88.69%
The cost of doing business (specifically, the cost of real estate, wages and salaries, and utilities) is…	**1** *Very poor relative to other regions* **7** *Very good relative to other regions*	168	3.66	26.19%	22.02%	51.79%
Specialized facilities for research (e.g., science laboratories, university research institutions and technical libraries) are…	**1** *Limited* **7** *Readily available*	167	5.89	86.83%	6.59%	6.59%
The institutions in your region that perform basic research…	**1** *Rarely transfer knowledge to your industry* **7** *Frequently transfer knowledge to your industry*	166	5.11	69.28%	14.46%	16.27%
The communications infrastructure (including internet access) in your region…	**1** *Fails to satisfy your business needs* **7** *Fully satisfies your business needs*	168	5.79	84.52%	11.31%	4.17%
Qualified scientists and engineers in your region are…	**1** *Scarce* **7** *In ample supply*	167	4.27	53.89%	9.58%	36.53%
The available pool of skilled workers in your region…	**1** *Is too small and hinders your growth* **7** *Is sufficient to meet your growth needs*	168	4.05	39.29%	19.64%	41.07%
The overall quality of the K-12 education system is…	**1** *Very poor* **7** *Very high*	163	3.71	28.83%	30.67%	40.49%

High = 5,6,7 Neutral = 4 Low = 1,2,3

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY

Measure	Description of Rating Scale	Number of Respondents	Average	High	Neutral	Low
Advanced educational programs (e.g., vocational schools, colleges and /or universities)…	**1** *Provide your business with low quality employees* **7** *Provide your business with high quality employees*	166	5.25	77.11%	16.27%	6.63%
Local access to risk capital (e.g. venture funds and private equity investments) is…	**1** *Difficult* **7** *Easy*	167	4.32	52.69%	20.36%	26.95%
The overall quality of life (e.g., climate, cultural and recreational opportunities) in the region)…	**1** *Makes recruitment and retention of employees difficult* **7** *Makes recruitment and retention of employees easy*	167	6.20	93.41%	4.79%	1.80%
The cost of living in your region…	**1** *Makes recruitment and retention of employees difficult* **7** *Makes recruitment and retention of employees easy*	168	3.01	14.88%	12.50%	72.62%
Regional customers for your business's products/services are…	**1** *Unsophisticated and undemanding* **7** *Sophisticated and demanding*	111	4.86	55.86%	33.33%	10.81%
Regional customers for your business' products/services have…	**1** *No special needs that impact your product offering* **7** *Special needs that often impact your product offering*	112	4.30	46.43%	27.68%	25.89%
Feedback from regional customers to improve your business's products/services is…	**1** *Infrequent and does not reveal the need for new features or enhanced performance* **7** *Frequent and reveals the need for new features or enhanced performance*	113	4.16	42.48%	30.09%	27.43%
State and regional regulations affecting your business are…	**1** *Are inappropriate and hinder your firm's ability to succeed* **7** *Are appropriate and assist you firm's ability to succeed*	117	3.50	17.95%	38.46%	43.59%

High = 5,6,7 Neutral = 4 Low = 1,2,3

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY

Measure	Description of Rating Scale	Number of Respondents	Average	High	Neutral	Low
The state and regional environmental standards and safety regulations…	**1** *Are lax* **7** *Are strict*	165	5.65	81.21%	16.36%	2.42%
Investment in R&D is…	**1** *Discouraged by state and regional taxes and incentives* **7** *Encouraged by state and regional taxes and incentives*	161	4.06	38.51%	34.78%	26.71%
State and local government support for investment in R&D (e.g. funding business incubators, creating consortia)…	**1** *Is scant* **7** *Is ample*	162	3.54	25.93%	23.46%	50.62%
Government's overall responsiveness and ability to work with the needs of business is…	**1** *Low* **7** *High*	163	3.64	31.29%	23.31%	45.40%
The number of regional competitors for your business in your region is…	**1** *Low* **7** *High*	116	4.20	51.72%	7.76%	40.52%
Regional competition in your industry is…	**1** *Mild* **7** *Intense*	117	4.50	56.41%	12.82%	30.77%
Specialized suppliers of your business's materials, components, machinery, and services are…	**1** *Mostly not available inside your region* **7** *Mostly available inside your region*	115	4.40	53.91%	10.43%	35.65%
Regional specialized suppliers of your business's materials, components, machinery, and services are…	**1** *Of very low quality* **7** *Comparable with the best quality elsewhere*	112	5.04	65.18%	23.21%	11.61%

High = 5,6,7 Neutral = 4 Low = 1,2,3

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY

Measure	Description of Rating Scale	Number of Respondents	Average	High	Neutral	Low
Regional specialized suppliers assist your firm with new product and process development …	**1** *Infrequently* **7** *Frequently*	114	3.93	44.74%	19.30%	35.96%
Businesses in your region…	**1** *Hide information from other firms even when there is not a competitive reason to do so* **7** *Share information openly with other businesses*	114	4.16	34.21%	41.23%	24.56%
Your cluster…	**1** *Is still emerging, with a narrow range of firms and institutions involved* **7** *Is well developed with a broad range of firms and institutions involved*	116	4.61	60.34%	9.48%	30.17%
Relationships between firms and organizations in your cluster…	**1** *Do little to assist your R&D efforts* **7** *Are very important to your R&D efforts*	116	3.92	43.97%	13.79%	42.24%
Associations and organizations that represent your cluster…	**1** *Do not exist or are ineffective* **7** *Exist and effectively promote the interests of the cluster*	116	4.74	59.48%	12.07%	28.45%
Firms in your cluster…	**1** *Have no preference for the geographic location of their business partners* **7** *Prefer to work with firms located in the region*	114	3.59	39.47%	14.04%	46.49%
Firms and organizations in your cluster…	**1** *Infrequently share knowledge* **7** *Frequently share knowledge*	116	4.02	50.00%	14.66%	35.34%
Firms and organizations in your cluster…	**1** *Rarely contribute to cluster-wide programs* **7** *Frequently contribute to cluster-wide programs*	115	4.19	53.91%	9.57%	36.52%

High = 5,6,7 Neutral = 4 Low = 1,2,3

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY

Measure	Description of Rating Scale	Number of Respondents	Average	High	Neutral	Low
Firms and organizations in your cluster…	**1** *Are unwilling to accept new members into cluster activities and organizations* **7** *Treat entrepreneurs, start-ups, and new companies as full partners in all aspects of cluster cooperation*	116	4.97	68.97%	17.24%	13.79%
Firms in your cluster…	**1** *Have no advantage in perceiving new buyer trends compared to firms who are not in a cluster* **7** *Perceive new buyer trends more rapidly than your competitors who do not operate within a cluster*	112	4.16	37.50%	39.29%	23.21%
Finally, considering all the significant factors, including government, industry and social factors, how good a location is your region as a place to innovate in your business?	**1** *Very poor location* **7** *Very good location*	167	5.45	83.83%	6.59%	9.58%

High = 5,6,7 Neutral = 4 Low = 1,2,3

Measure	Description of Rating Scale	Number of Respondents	Avg.	Frequently	Sometimes	Never
idea: Universities	**1** *Never* **2** *Sometimes* **3** *Frequently*	115	1.99	24.35%	50.43%	25.22%
idea: Community Colleges	**1** *Never* **2** *Sometimes* **3** *Frequently*	114	1.20	3.51%	13.16%	83.33%
idea: Public or Private Research Organizations (Salk, scripps)	**1** *Never* **2** *Sometimes* **3** *Frequently*	115	1.82	18.26%	45.22%	36.52%
idea: Regional Customers	**1** *Never* **2** *Sometimes* **3** *Frequently*	114	1.89	19.30%	50.00%	30.70%

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY

Measure	Description of Rating Scale	Number of Respondents	Average	Frequently	Sometimes	Never
idea: Other firms in your industry	**1** *Never* **2** *Sometimes* **3** *Frequently*	115	2.11	22.61%	66.09%	11.30%
idea: Regional Suppliers	**1** *Never* **2** *Sometimes* **3** *Frequently*	112	1.67	8.93%	49.11%	41.96%
idea: Venture Capital Firms	**1** *Never* **2** *Sometimes* **3** *Frequently*	115	1.58	5.22%	47.83%	46.96%
idea: Business Incubators	**1** *Never* **2** *Sometimes* **3** *Frequently*	115	1.37	8.70%	20.00%	71.30%
idea: Industry or Cluster Associations	**1** *Never* **2** *Sometimes* **3** *Frequently*	114	1.91	18.42%	54.39%	27.19%
idea: Business Assistance Centers (RTA, SBA)	**1** *Never* **2** *Sometimes* **3** *Frequently*	112	1.21	1.79%	17.86%	80.36%
develop: Universities	**1** *Never* **2** *Sometimes* **3** *Frequently*	115	1.80	13.91%	52.17%	33.91%
develop: Community Colleges	**1** *Never* **2** *Sometimes* **3** *Frequently*	114	1.10	1.75%	6.14%	92.11%
develop: Public or Private Research Centers (salk, scripps)	**1** *Never* **2** *Sometimes* **3** *Frequently*	115	1.55	6.09%	42.61%	51.30%
develop: Regional Customers	**1** *Never* **2** *Sometimes* **3** *Frequently*	115	1.68	7.83%	52.17%	40.00%

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY

Measure	Description of Rating Scale	Number of Respondents	Average	Frequently	Sometimes	Never
develop: Other Firms in Your Industry	**1** *Never* **2** *Sometimes* **3** *Frequently*	116	1.82	10.34%	61.21%	28.45%
develop: Regional Suppliers	**1** *Never* **2** *Sometimes* **3** *Frequently*	115	1.50	2.61%	45.22%	52.17%
develop: Venture Capital Firms	**1** *Never* **2** *Sometimes* **3** *Frequently*	115	1.35	0.87%	33.04%	66.09%
develop: Business Incubators	**1** *Never* **2** *Sometimes* **3** *Frequently*	114	1.19	2.63%	14.04%	83.33%
develop: Industry or Cluster Associations	**1** *Never* **2** *Sometimes* **3** *Frequently*	115	1.55	5.22%	44.35%	50.43%
develop: Business Assistance Centers (RTA, SBA)	**1** *Never* **2** *Sometimes* **3** *Frequently*	110	1.14	0.00%	13.64%	86.36%
commerce: Universities	**1** *Never* **2** *Sometimes* **3** *Frequently*	110	1.26	3.64%	19.09%	77.27%
commerce: Community Colleges	**1** *Never* **2** *Sometimes* **3** *Frequently*	110	1.12	2.73%	6.36%	90.91%
commerce: Public or Private Research Centers (salk, scripps)	**1** *Never* **2** *Sometimes* **3** *Frequently*	111	1.23	1.80%	19.82%	78.38%
commerce: Regional Customers	**1** *Never* **2** *Sometimes* **3** *Frequently*	110	1.70	5.45%	59.09%	35.45%

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY

Measure	Description of Rating Scale	Number of Respondents	Average	Frequently	Sometimes	Never
commerce: Other Firms in Your Industry	**1** *Never* **2** *Sometimes* **3** *Frequently*	112	1.76	11.61%	52.68%	35.71%
commerce: Regional Suppliers	**1** *Never* **2** *Sometimes* **3** *Frequently*	111	1.54	2.70%	48.65%	48.65%
commerce: Venture Capital Firms	**1** *Never* **2** *Sometimes* **3** *Frequently*	111	1.30	0.90%	27.93%	71.17%
commerce: Business Incubators	**1** *Never* **2** *Sometimes* **3** *Frequently*	110	1.14	2.73%	8.18%	89.09%
commerce: Industry or Cluster Associations	**1** *Never* **2** *Sometimes* **3** *Frequently*	111	1.50	6.31%	36.94%	56.76%
commerce: Business Assistance Centers (RTA, SBA)s	**1** *Never* **2** *Sometimes* **3** *Frequently*	106	1.15	0.94%	13.21%	85.85%

Measure	Description of Rating Scale	Number of Respondents	Average	>75%	50-74%	25-49%
What proportion of idea generation is done within your firm, as opposed to by/with any of the institutions listed above?	**1** *Less than 25%* **2** *25% to 50%* **3** *50% to 75%* **4** *Greater than 75%* **9** *Not applicable*	111	3.49	68.47%	18.02%	7.21%
What proportion of idea development is done within your firm, as opposed to by/with any of the institutions listed above?	**1** *Less than 25%* **2** *25% to 50%* **3** *50% to 75%* **4** *Greater than 75%* **9** *Not applicable*	108	3.55	74.07%	13.89%	4.63%
What proportion of commercialization is done within your firm, as opposed to by/with any of the institutions listed above?	**1** *Less than 25%* **2** *25% to 50%* **3** *50% to 75%* **4** *Greater than 75%* **9** *Not applicable*	105	3.56	73.33%	14.29%	7.62%

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY

Measure	Description of Rating Scale	Number of Respondents	Average	Satisfied	Neutral	Unsatisfied
sat: Universities	**1** *Unsatisfied* **7** *Satisfied*	97	4.97	64.95%	18.56%	16.49%
sat: Community Colleges	**1** *Unsatisfied* **7** *Satisfied*	77	3.49	12.99%	51.95%	35.06%
sat: Public or Private Research Centers (salk, scripps)	**1** *Unsatisfied* **7** *Satisfied*	93	4.67	54.84%	29.03%	16.13%
sat: Regional Customers	**1** *Unsatisfied* **7** *Satisfied*	94	4.52	52.13%	35.11%	12.77%
sat: Other Firms in Your Industry	**1** *Unsatisfied* **7** *Satisfied*	100	4.67	58.00%	30.00%	12.00%
sat: Regional Suppliers	**1** *Unsatisfied* **7** *Satisfied*	94	4.21	43.62%	35.11%	21.28%
sat: Venture Capital Firms	**1** *Unsatisfied* **7** *Satisfied*	90	3.78	40.00%	30.00%	30.00%
sat: Business Incubators	**1** *Unsatisfied* **7** *Satisfied*	78	3.38	14.10%	44.87%	41.03%
sat: Industry Associations	**1** *Unsatisfied* **7** *Satisfied*	91	4.55	56.04%	29.67%	14.29%
sat: Business Assistance Centers (RTA, SBA)	**1** *Unsatisfied* **7** *Satisfied*	69	3.51	17.39%	53.62%	28.99%

Satisfied = 5,6,7 Neutral = 4 Unsatisfied = 1,2,3

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY

Measure	Description of Rating Scale	Number of Respondents	Average	Very Helpful	Helpful	Not Helpful
entrepren: University-based networking organizations	**1** *Not at all helpful* **5** *Critically helpful*	163	3.34	50.31%	23.93%	25.77%
entrepren: University technology transfer offices	**1** *Not at all helpful* **5** *Critically helpful*	160	2.64	21.88%	31.25%	46.88%
entrepren: Regional industry or cluster councils	**1** *Not at all helpful* **5** *Critically helpful*	159	2.95	33.96%	33.33%	32.70%
entrepren: National trade associations	**1** *Not at all helpful* **5** *Critically helpful*	159	2.67	16.35%	44.65%	38.99%
entrepren: Economic development organizations	**1** *Not at all helpful* **5** *Critically helpful*	160	2.56	21.25%	31.25%	47.50%
estab co: University-based networking organizations	**1** *Not at all helpful* **5** *Critically helpful*	161	3.02	36.02%	31.06%	32.92%
estab co: University technology transfer offices	**1** *Not at all helpful* **5** *Critically helpful*	160	2.57	18.13%	35.00%	46.88%
estab co: Regional industry or cluster councils	**1** *Not at all helpful* **5** *Critically helpful*	157	2.85	29.30%	36.94%	33.76%
estab co: National trade associations	**1** *Not at all helpful* **5** *Critically helpful*	157	2.87	22.93%	47.13%	29.94%
estab co: Economic development organizations	**1** *Not at all helpful* **5** *Critically helpful*	158	2.64	24.05%	31.01%	44.94%

Very Helpful = 4,5 Helpful = 3 Not Helpful = 1,2

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY

Measure	Description of Rating Scale	Number of Respondents	Average	Very Helpful	Helpful	Not Helpful
policies: University-based networking organizations	**1** *Never* **2** *Sometimes* **3** *Frequently*	157	2.62	22.29%	30.57%	47.13%
policies: University technology transfer offices	**1** *Never* **2** *Sometimes* **3** *Frequently*	155	1.98	5.16%	25.81%	69.03%
policies: Regional industry or cluster councils	**1** *Never* **2** *Sometimes* **3** *Frequently*	155	3.06	34.84%	36.13%	29.03%
policies: National trade associations	**1** *Never* **2** *Sometimes* **3** *Frequently*	155	3.02	36.77%	32.26%	30.97%
policies: Economic development organizations	**1** *Never* **2** *Sometimes* **3** *Frequently*	156	2.74	28.85%	27.56%	43.59%

Very Helpful = 4,5 Helpful = 3 Not Helpful = 1,2

Measure	Description of Rating Scale	Number of Respondents	Average	Beneficial	Neutral	Not Beneficial
How beneficial is your physical location in San Diego to your firm's ability to innovate?	**1** *Not at all beneficial* **5** *Critically beneficial*	116	3.05	38.79%	31.03%	30.17%
In five years, how beneficial do you think your physical location in San Diego will be to your firm's ability to innovate?	**1** *Not at all beneficial* **5** *Critically beneficial*	116	3.09	38.79%	32.76%	28.45%

Beneficial = 4,5 Neutral = 3 Not Beneficial = 1,2

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY

Measure	Description of Rating Scale	Number of Respondents	Average	Agree	Neutral	Disagree
Companies that share lots of information with each other lose their competitive edge.	**1** *Agree* **7** *Disagree*	164	3.21	24.39%	10.37%	65.24%
Intense local competition between companies tends to contribute positively to the standard of living of the average citizen.	**1** *Agree* **7** *Disagree*	164	4.54	60.37%	14.63%	25.00%
Companies that compete against each other in the region should establish closer ties and cooperative agreements than they have now.	**1** *Agree* **7** *Disagree*	164	4.22	43.29%	33.54%	23.17%
Entry of a new competitor in the region benefits the business environment.	**1** *Agree* **7** *Disagree*	164	2.48	5.49%	10.98%	83.54%
Companies in close geographic proximity often end up sharing information that they otherwise would not.	**1** *Agree* **7** *Disagree*	164	4.71	61.59%	18.29%	20.12%
Presence of intense local competition between companies tends to foster innovation	**1** *Agree* **7** *Disagree*	164	5.46	81.71%	10.98%	7.32%
Where possible, companies should seek to train workers through co-operative training programs, rather than on their own.	**1** *Agree* **7** *Disagree*	164	4.45	50.61%	25.00%	24.39%
For most firms, the benefits of having local competitors outweigh the costs.	**1** *Agree* **7** *Disagree*	163	4.81	61.96%	21.47%	16.56%

Agree = 5,6,7 Neutral = 4 Disagree = 1,2,3

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY

Measure	Description of Rating Scale	Number of Respondents	Average	Agree	Neutral	Disagree
Projects that require cooperation and collaboration between firms in my region tend to cost more then they return.	**1** *Agree* **7** *Disagree*	158	3.41	17.72%	32.28%	50.00%
Employees at every level of a company should be encouraged to exchange non-proprietary information with their peers at other firms.	**1** *Agree* **7** *Disagree*	164	4.12	50.00%	12.20%	37.80%
It is possible for companies to collaborate and compete at the same time.	**1** *Agree* **7** *Disagree*	164	5.35	81.71%	6.71%	11.59%
Cooperation between local firms has contributed directly to the prosperity of the region as a whole.	**1** *Agree* **7** *Disagree*	164	4.99	64.63%	24.39%	10.98%
Companies are worse off when they have to compete with other local companies to attract and retain skilled workers.	**1** *Agree* **7** *Disagree*	164	3.88	39.02%	14.02%	46.95%
Intense local competition between companies tends to help them increase productivity.	**1** *Agree* **7** *Disagree*	164	4.96	73.78%	14.02%	12.20%
Firms in clusters…are better prepared to compete vs. isolated competitors.	**1** *Agree* **7** *Disagree*	163	5.53	84.05%	8.59%	7.36%
Firms in clusters…benefit indirectly when other firms in the cluster succeed.	**1** *Agree* **7** *Disagree*	163	5.49	85.89%	9.20%	4.91%

Agree = 5,6,7 Neutral = 4 Disagree = 1,2,3

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY

Measure	Description of Rating Scale	Number of Respondents	Average	Agree	Neutral	Disagree
Firms in clusters…are better protected from national economic downturns	**1** *Agree* **7** *Disagree*	163	4.36	42.33%	34.36%	23.31%
Firms in clusters…innovate at the same rate as firms not in clusters	**1** *Agree* **7** *Disagree*	162	3.29	16.67%	23.46%	59.88%
Firms in clusters…are more susceptible to downturns in their industry	**1** *Agree* **7** *Disagree*	163	3.52	16.56%	35.58%	47.85%

Agree = 5,6,7 Neutral = 4 Disagree = 1,2,3

Measure	Description of Rating Scale	Number of Respondents	Average	Fundamental Change	Some Impact	Some Change
To what degree has e-commerce (web-based and other electronic commerce) impacted your business operations	**1** *Hardly at all* **2** *Some impact* **3** *Significant impact on business model* **4** *Fundamentally changed business model*	113	2.35	7.08%	34.51%	40.71%

Fundamental Change = 4 Significant Impact = 3 Some Change = 2

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY

Measure	Description of Rating Scale	Number of Respondents	Average	Important	Neutral	Not Important
Promote world-class primary and secondary education	**1** *Not at all important* **7** *Critically important*	166	4.42	89.76%	7.83%	2.41%
Promote specialized education and training programs to upgrade worker skills	**1** *Not at all important* **7** *Critically important*	165	3.79	66.06%	24.24%	9.70%
Implement tax reform to encourage investment in innovation (e.g., R&D tax credits)	**1** *Not at all important* **7** *Critically important*	167	3.83	65.87%	27.54%	6.59%
Speed up regulatory approval processes in line with product life-cycles	**1** *Not at all important* **7** *Critically important*	165	3.72	63.03%	21.21%	15.76%
Simplify compliance procedures for government regulations (e.g., one-stop filing, websites, etc)	**1** *Not at all important* **7** *Critically important*	167	3.81	65.87%	27.54%	6.59%
Reform liability laws to stimulate and reward next generation product innovation and safety	**1** *Not at all important* **7** *Critically important*	164	3.54	50.61%	31.10%	18.29%
Promote antitrust legislation to encourage competition	**1** *Not at all important* **7** *Critically important*	163	2.52	20.86%	24.54%	54.60%
Support the particular needs of start-up companies (access to capital, incubators, management training)	**1** *Not at all important* **7** *Critically important*	167	3.51	53.89%	29.34%	16.77%

Important = 4,5 Neutral = 3 Not Important = 1,2

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY

Measure	Description of Rating Scale	Number of Respondents	Average	High	Neutral	Low
Strengthen and modernize intellectual property protections (patents, copyrights) at home and abroad	**1** *Not at all important* **7** *Critically important*	164	3.66	63.41%	25.00%	11.59%
Provide services to assist and promote regional exports	**1** *Not at all important* **7** *Critically important*	166	2.83	27.11%	33.13%	39.76%
Improve information and communications infrastructure	**1** *Not at all important* **7** *Critically important*	163	3.36	43.56%	37.42%	19.02%
Assist in attracting suppliers and service providers from other locations	**1** *Not at all important* **7** *Critically important*	162	2.66	24.69%	29.63%	45.68%
Government support for funding of specialized research institutes, labs, etc.	**1** *Not at all important* **7** *Critically important*	165	3.27	40.61%	35.15%	24.24%
Catalyze partnerships among government, industry and universities.	**1** *Not at all important* **7** *Critically important*	163	3.14	35.58%	38.04%	26.38%
Improve transportation and other physical infrastructure	**1** *Not at all important* **7** *Critically important*	162	4.17	78.40%	16.67%	4.94%
Increase funding for university-based research	**1** *Not at all important* **7** *Critically important*	165	3.46	46.67%	32.73%	20.61%

appendix 3
MEASURING PRODUCTIVITY

Census Bureau data on "shipments" in 1997 serve as the basis for measuring industry productivity. Shipments data include "sales, shipments, receipts, revenue, or business done by establishments within the scope of the Economic Census."[94] The Census Bureau reports figures using the 1997 NAICS codes. In order to make the data comparable to County Business Pattern (CBP), we have to build a concordance between NAICS and 1987 U.S. SIC codes. The concordance is based on a bridging methodology provided by the 1997 Economic Census. The bridge shows each SIC industry, and identifies the NAICS or parts of NAICS that comprise them. The weights of each NAICS code assigned to an SIC industry in the concordance matrix are based on the proportions of total sales/receipts/shipments each NAICS accounts for that SIC code.[95]

To calculate productivity, we divide total industry shipments by total industry employment. For example, in 1997, San Diego County firms in the shipbuilding and repair industry produced total shipments of $786,000,000. In the same year, this industry employed 6,759 people in San Diego County, and hence their productivity was $116,289 per worker.

To utilize these productivity figures, we index a region's productivity to the national average.[96] An index of 100 means that a given region's productivity equals the nation's average productivity for that industry; an index of 110 means a region is 10% more productive then the national average.

The CBP database lists 720 SIC industries in San Diego County in 1997. However, information is not available for every NAICS industry. The Agriculture, and Public Administration sectors are not covered in the 1997 Economic Census. Mining, Utilities, Construction, Transportation and Warehousing, Finance and Insurance, and Management of Companies and Enterprises sector are not reported at county level. This leaves data for 365 SIC industries. Furthermore, similar to CBP data, some of Economic Census data is withheld to avoid disclosing information about specific companies. Among the 365 SIC industries, the Census Bureau suppresses sales/receipts/shipments data on 29 of them. Therefore, we calculate a productivity index for 336 industries in San Diego in 1997.[97]

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94 For a more detailed definition see: http://www.census.gov/epcd/ec97brdg/def/ECVALUE.HTM.

95 These proportions are calculated at the national level. Any given county, however, will not perfectly mirror the U.S. economy in terms of the proportion of types of firms within a given NAICS code. We calculate a productivity index for 336 4-digit SIC industries in San Diego; 182 of these contain data from fractions of a NAICS industry.

96 For example, shipments per worker in "shipbuilding and repair" for the entire United States was $108,557. So, San Diego's productivity indexed to U.S. productivity equals 107 [($116,289/$108557)*100].

97 Data for some SIC industries are an aggregation of data from several NAICS industries. In San Diego, 39 SIC industries depend on data from one or more NAICS industry for which the sales/receipts/shipments data is suppressed. Because suppression occurs when there are few firms in a NAICS code, this problem should not significantly skew the figures, so we report the productivity index based on the data available.

ABOUT
THE CLUSTERS OF INNOVATION INITIATIVE PARTICIPANTS

MICHAEL E. PORTER

Michael E. Porter is the Bishop William Lawrence University Professor at Harvard Business School and a leading authority on competitive strategy and international competitiveness. He co-chairs the Clusters of Innovation Initiative at the Council on Competitiveness and is a member of the Council's executive committee.

The author of 16 books and over 75 articles, Professor Porter's ideas have guided economic policy throughout the world. Professor Porter has led competitiveness initiatives in nations and states such as Canada, India, New Zealand, and Connecticut; guides regional projects in Central America and the Middle East; and is co-chairman of the Global Competitiveness Report. In 1994, Professor Porter founded the Initiative for a Competitive Inner City, a non-profit private sector initiative formed to catalyze business development in distressed inner cities across the United States. The holder of eight honorary doctorates, Professor Porter has won numerous awards for his books, articles, public service, and influence on several fields.

COUNCIL on COMPETITIVENESS

The Council is a nonprofit, 501(c)(3) organization whose members are corporate chief executives, university presidents, and labor leaders dedicated to setting an action agenda to drive U.S. economic competitiveness and leadership in world markets. The Council helps shape the national debate on competitiveness by concentrating on a few critical issues including technological innovation, workforce development, and the benchmarking of U.S. economic performance against other countries.

The Council's work is guided by a 30 member executive committee. Chief executives of 40 of the country's most prominent nonprofit research organizations, professional societies and trade associations contribute their expertise as national affiliates of the Council.

MONITOR GROUP

Monitor Group is a family of competitive service firms linked by shared ownership, management philosophy, and inter-related assets. Each entity in the Group is dedicated to providing products and services which fundamentally enhance the competitiveness of our clients. Our aspiration is to operate as an "intelligent switch" in a closely-linked global network of expertise and experience, not merely as a narrowly defined consulting firm, a research company or a merchant bank. We are dedicated to creating innovative, winning, action-oriented solutions by deploying our human, knowledge, and social assets in unique combinations dictated by each client's unique circumstances — consulting interventions, capital infusions, deal structuring, management development programs, customized software, cutting-edge market research, and so on as appropriate.

Monitor Group is organized into three major operating units:

- **Monitor Action Group**, which consults to top management to help resolve their most important and intractable competitive problems;
- **The Monitor Merchant Banking Group**, which marries capital investment with advisory services to enhance company competitiveness;
- **The Intelligent Products Group**, which provides customized data and software products to support competitive decision making.

ontheFRONTIER

ontheFRONTIER, a Monitor Group company, has extensive experience in competitiveness assessment and cluster development projects throughout the United States and the world. Our private and public sector client base spans over twenty countries in North and South America, Europe, Asia, Africa and the Middle East. In addition, we have collaborated extensively with development agencies such as the World Bank Group and the United States Agency for International Development (USAID) on microeconomic development issues.

ontheFRONTIER's work focuses on improving business competitiveness through building winning strategies, fostering cooperation among clusters of firms, and facilitating productive dialogue between private and public sector leaders to promote innovation. Our vast network of partners forms the basis of our collaborative effort to diffuse a new web-based set of offerings. We are working with financial institutions, industry associations, multilateral agencies, and others to diffuse web-based business strategy tools and insights to businesspeople around the world. For more information, please visit www.ontheFRONTIER.com.

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