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

Research Triangle

CLUSTERS OF INNOVATION INITIATIVE

- ATLANTA
- PITTSBURGH
- RESEARCH TRIANGLE
- SAN DIEGO
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CLUSTERS OF INNOVATION INITIATIVE: REGIONAL FOUNDATIONS OF U.S. COMPETITIVENESS

CONTENTS

Foreword by the Co-Chairs of the Clusters of Innovation Initiative

Since its founding nearly two decades ago, the Council on Competitiveness has addressed a wide range of economic issues affecting the nation including trade policy, technology policy, the federal budget, and workforce skills. Competitiveness has tended to be seen primarily from a federal perspective, and national policies and circumstances surely affect the prosperity of our economy. However, the Clusters of Innovation Initiative was undertaken with the realization that the real work of raising productivity and innovative capacity usually occurs not in our nation's capital, but in the cities and regions where firms are based and competition actually takes place.

Regional economies are the building blocks of United States 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. Understanding is growing about how these clusters enhance productivity and spur innovation by bringing together technology, information, specialized talent, competing companies, academic institutions, and other organizations. Close proximity, and the accompanying tight linkages, yield 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 now able to systematically measure the relative strength of regional economies and their clusters and track their economic and innovation performance over time. In addition, a team consisting of individuals at Monitor Group and its affiliate ontheFRONTIER, the Council on Competitiveness, and the Institute have conducted surveys, in-depth interviews, and strategic analyses in order to assess the strengths and challenges of the region.

This regional report examines the composition and performance of the Research Triangle regional economy, how industry clusters developed and innovation arose, how clusters affected the region's economic future, and how the region can establish a strategy and action program to drive its economy and clusters forward. The framework employed and the lessons learned apply to many regions of the country.

We wish to acknowledge the support we received from the national steering committee, advisors in the Research Triangle region, the many individuals who gave their valuable time to be surveyed and interviewed, and the many project sponsors. All of you have helped us to create a unique knowledge base and a process for catalyzing action. Your thoughts and insights are embedded in this report, and will, hopefully, benefit not only the five regions that participated in the study but other parts of the country as well.

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

ACKNOWLEDGEMENTS

This report benefits from the leadership of co-chairs Duane Ackerman of BellSouth Corporation and Professor Michael Porter of Harvard University, as well as a national steering committee. They have guided a partnership involving Monitor Group and its affiliate, ontheFRONTIER, the Institute for Strategy and Competitiveness at Harvard Business School, and the Council on Competitiveness.

The North Carolina Department of Commerce, the Kenan Institute, GlaxoSmithKline, the Greater Raleigh Chamber of Commerce, and the Research Triangle Foundation generously provided underwriting for this report.

Professor Porter provided theoretical and methodological framework for the Initiative and led the research and writing of this report.

Jeff Grogan of the Monitor Group served as overall project leader. Kurt Dassel of the Monitor Group managed the efforts in each of the five regions studied. Pedro Arboleda and Kurt Dassel of the Monitor Group, with assistance and guidance from Jeff Grogan and Mark Fuller of the Monitor Group, took the lead in preparing this report. These four individuals performed the basic economic and cluster analyses and were the primary contacts with business and government leaders in each region.

The Institute for Strategy and Competitiveness, led by Professor Porter, conducted the Cluster Mapping Project, a multi-year research effort that developed the data for benchmarking regional and cluster performance. Elisabeth de Fontenay, Weifeng Weng, and Daniel Vasquez at the Institute for Strategy and Competitiveness contributed to the conceptual development of the project and the interpretation of economic and cluster data presented in the regional reports and the national report. Other Institute staff members who participated include Christian Ketels, Veronica Ingham, and Orjan Solvell.

John Yochelson and Alan Magazine at the Council on Competitiveness provided project coordination and interfaced with business and government leaders. Michelle Lennihan coordinated the fieldwork, performed data analysis, and contributed to the regional and national reports. Debra VanOpstal and Jackie Mathewson provided additional national economic data and analysis, as well as ongoing review and critique of the research. Judith Phair and Lea Kleinschmidt at the Council on Competitiveness and Jodie Klein, KleinOnPoint, helped communicate the findings of the regional and national reports to the media and other groups.

Lily Rappoli, Alyson Lee, and Julie Sherman at the DesignStudio at Monitor Group illustrated, designed, and created the layout of the regional reports and this report.

Almost 300 business and government leaders contributed to this project in some way by providing background information, submitting to interviews, completing surveys, and offering their views. Regional advisors provided the Initiative valuable information and coordination assistance in the region, including

Molly Corbett Broad, President of the University of North Carolina, Harvey Schmitt, President of the Greater Raleigh Chamber of Commerce, James Roberson, President of the Research Triangle Foundation, Thomas White, President of the Greater Durham Chamber of Commerce, and Charles Hayes, President of the Research Triangle Regional Partnership.

MarketTools, Inc., provided the project with an on-line survey capability, Pam Wall, Executive Director at the Greater Triangle Regional Council, helped coordinate interviews and surveys in the Research Triangle, provided important background information, and made helpful suggestions.

While this report aims to reflect the consensus of those interviewed and surveyed, it cannot do justice to all their contributions. 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 or Pedro Arboleda at Monitor Group (e-mail: Kurt_Dassel@Monitor.com, Pedro_Arboleda@Monitor.com), or Michelle Lennihan at the Council on Competitiveness (e-mail: Lennihan@compete.org).

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Pam Wall, Executive Director, *Greater Triangle Regional Council*
Thomas J. White, President and CEO, *Greater Durham Chamber of Commerce*

HIGHLIGHTS

Regional Innovative Capacity and Economic Competitiveness

- The economic goal for the Research Triangle should be a high and rising standard of living.
- This depends upon creating a high-quality business environment that 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.

Accomplishments

- A small group of leaders were able to make things happen by investing in education, developing world-class research centers, and establishing the Research Triangle Park.
- The Research Triangle metro area was able to recruit major corporations in the pharmaceutical / biotechnology and communications equipment clusters.
- The region developed the capacity to create new firms and industries from local knowledge centers.
- Local leaders built effective institutions for collaboration.

Assets

These accomplishments have left the Research Triangle metro area with a number of assets:

- Research Triangle Park and specialized research centers across different clusters.
- Positions in fast-growing industry clusters.
- Competitive cost position versus other technology centers.
- Good workforce training infrastructure and leading research universities
- High levels of federal and state R&D investments.
- Good standard of living and relatively low unemployment, which have led to a high quality of life.

Challenges

At the same time, the Research Triangle faces a number of challenges it must address in order to boost regional prosperity:

- Research Triangle's road and air infrastructure have proved to be inadequate for current growth needs.
- Regional K-12 education is lagging.
- The region suffers from weak technology commercialization structure.

- Historical focus on a limited array of clusters has led to a dependence on a few clusters (e.g., communications equipment), which exacerbates the situation during downturns in the economy.
- Lack of large corporate headquarters in the region limits community sponsorship and leadership from corporations in the area.
- Weak collaboration among communities.
- Low collaboration within many clusters.

The Need for New Directions

Our analysis identifies several ways in which the Research Triangle can transition from a fast growing economy to a diversified, mature, and strongly performing economy. The Research Triangle should move from:

- The Research Triangle Park to a new strategy for the region.
- "High-tech" clusters to a broader innovation economy.
- Metro area to Economic Area.

Opportunities

The Research Triangle can seize on a number of under-realized opportunities:

- Improve collaboration in the "high-tech" clusters of the past.
- Create a strategy to upgrade a wider array of clusters to include analytical instruments, medical devices, chemicals, textiles, and plastics.
- Develop new opportunities at the intersection of clusters, including environmental sciences, biotechnology and information technology, telecommunications and medicine, and biotechnology and agribusiness.
- Broaden the economy by integrating common clusters in the broader region.
- Attract and grow more home bases for the region.
- Establish an overarching organization for economic development that helps coordinate and routinize the process.

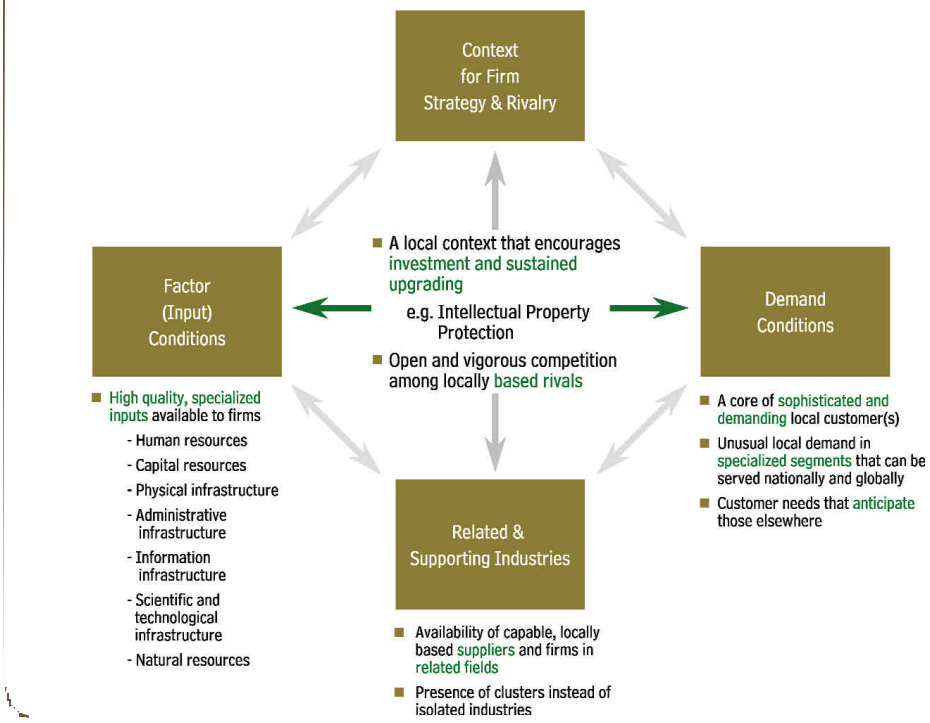
EXECUTIVE SUMMARY

The Determinants of Regional Innovation Capacity and Economic Competitiveness

The central economic goal for regions should be to attain and sustain a high and rising **standard of living** for their 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, and one not well understood by academics and policy-makers, 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. (See Exhibit 1 below).

Exhibit 1: Determinants of Regional Productivity



- **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** of nationally or internationally competitive industries. Clusters are 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. Aggressive rivalry in one industry spreads to other industries in the cluster through spin-offs or related diversification. Information flows freely, and innovation spreads rapidly through the relationships among customers and suppliers. Institutions such as colleges and universities adapt to cluster needs.

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

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, signaling the future, and so forth.

The Role of the Private Sector in the Business Environment

While government can help to create a favorable climate for competition, it is companies and industries that must ultimately achieve and sustain competitive advantage. To do so means they must recognize the central role of innovation. This means selling to the most demanding of buyers; seeking out buyers with the most difficult needs; establishing norms that exceed tough regulatory hurdles or product standards; and fostering a work environment of continuously upgrading skills and productivity.

The Role of 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. (See Exhibit 2 below.)

Exhibit 2: Selected Institutions for Collaboration, Research Triangle Region

Private Sector

- Research Triangle Foundation (RTF)
- Council for Entrepreneurial Development (CED)
- Greater Triangle Regional Council (GTRC)
- Research Triangle Institute (RTI)
- North Carolina Electronics and Information Technology Association (NCEITA)
- Duke University Medical Center (DUMC)
- North Carolina Citizens for Business and Industry (NCCBI)
- Durham, Raleigh, Cary, and Chapel Hill Chambers of Commerce

Joint Private/Public

- North Carolina Biotechnology Center (NCBC)
- Research Triangle Regional Partnership (RTRP)
- Microelectronics Center of North Carolina (MCNC)
- North Carolina State Univ. Centennial Campus
- North Carolina Information Highway (NCIH)
- Wake Education Partnership and Durham Public Education Network

Informal Networks

- IBM Alumni
- Cisco Alumni
- GlaxoSmithKline Alumni
- Univ. of North Carolina-Chapel Hill, North Carolina State Univ., Duke University and North Carolina Community College System Alumni
- North Carolina Governor's Boards and Taskforces

Public Sector

- University of North Carolina Health Care System
- National Institute of Environmental Health Sciences (NIEHS)
- Council of Governments (COG)
- Triangle Transit Authority (TTA)
- Center for Advanced Computing and Communication (CACC)

Source: Interviews, organizations, and websites

The Composition of Regional Economies

Regional economies are composed of four main types of activities:

- **Traded clusters.** Traded clusters are clusters that produce products and services that compete nationally and internationally.
- **Local clusters.** These are clusters that produce goods and services tied to the local market.
- **Resource-driven clusters**, in locations where natural resources of a particular type are abundant; and,
- **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. 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.

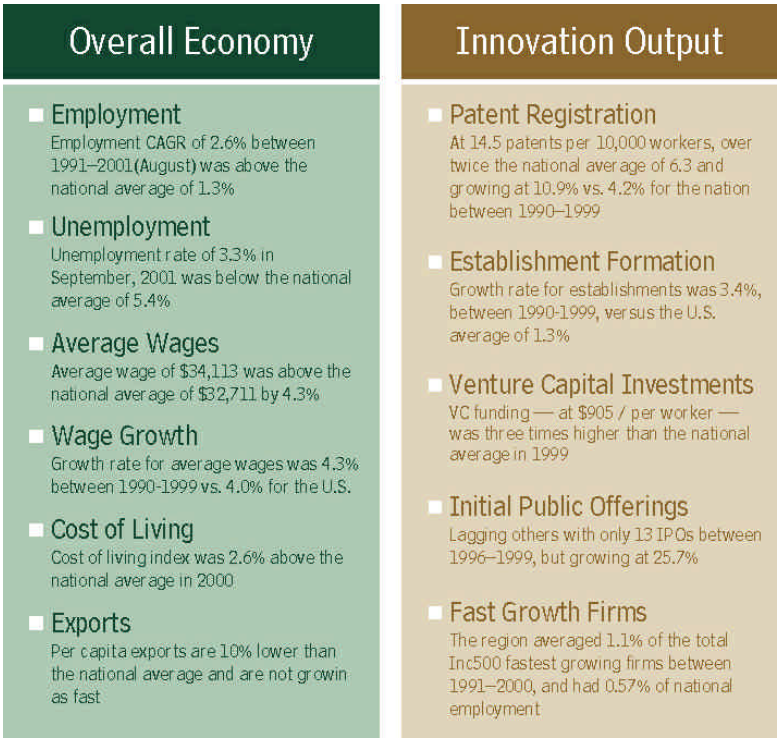
ECONOMIC PERFORMANCE, COMPOSITION, AND INNOVATIVE CAPACITY OF THE RESEARCH TRIANGLE REGIONAL ECONOMY

The Research Triangle economy does well in most most measures of performance (See Exhibit 3 on the following page). The recession and layoffs of the early 1990s was less severe in the Research Triangle than in other parts of the country, and the subsequent employment growth has been greater. The region has low unemployment rates, very high levels of R&D funding, and average wages slightly above the national average. Yet the cost of living is higher than the national average, and interviewees frequently expressed concern about the rising cost of living. Exports are 10% lower than the national average and not growing as fast.

Economic Indicators

- **Employment.** Annual employment growth rate from 1991 to 2001 (August) in the Research Triangle MSA was 2.6% versus 1.3% for the United States. Rapid employment growth helps explain why the Research Triangle was the 12th fastest growing MSA in the nation from 1990 to 2000.
- **Unemployment.** Unemployment in the Research Triangle MSA has recently risen from a low of 1.6% in 1999, to 3.3% in September 2001; a rate still below the national average of 5.4%. From 1991 to 2000 the region enjoyed one of the lowest unemployment rates in the nation, but the recent national economic downturn has spread to the region.
- **Average Wages.** Research Triangle MSA's average wages are $34,113, versus $32,711 for the United States, or approximately 4.3% above the national average. While higher than the national average, wage performance is not as high as other benchmark regions.
- **Wage Growth.** Research Triangle MSA's wage growth of 4.3% from 1991 to 1999 is slightly faster than the national average of 4.0%. However, growth in average wages has been slightly slower than other benchmark regions.

Exhibit 3: Summary of Economic Performance and Innovation Output in Research Triangle



Source: Bureau of Labor Statistics, Bureau of Economic Analysis; International Trade Administration; U.S. Patent and Trademark Office; Price Waterhouse Cooper Money Tree; Hoover's IPO Central; Inc. Magazine; American Chamber of Commerce Researchers Association

- **Cost of Living.** The Research Triangle MSA had a composite cost of living index of 102.6 in 2000, versus a national average of 100. Since regional wages are 4.3% higher than the national average, cost of living is mitigated by 2.1%.
- **Exports**. The Research Triangle exports approximately 10% less per capita than the national average, but annual export growth is faster than the nation. High levels of government, service-sector, and R&D employment tend to have a limiting affect on export numbers.

Innovation Output

The region's innovation output has also been strong over the past decade. Establishment formation has been growing at twice the national rate, venture capital (VC) investments per worker are high, and to too are patents per worker. Initial Public Offerings (IPOs), however, have been lagging the national average.

- **Patent Registration.** Research Triangle MSA's firms and organizations registered 14.5 patents per 10,000 workers in 1998, compared to the national average of 6.3. Research Triangle's per capita patent growth rate of 10.9% between 1990 and 1998 was ahead of the national growth rate of 4.2%.

High patent registration rates are partly the result of the success of local organizations in leveraging research and development efforts. Organizations of special mention in the Research Triangle region include IBM, Ericsson, Becton Dickison, North Carolina State University, University of North Carolina-Chapel Hill, and Duke University.

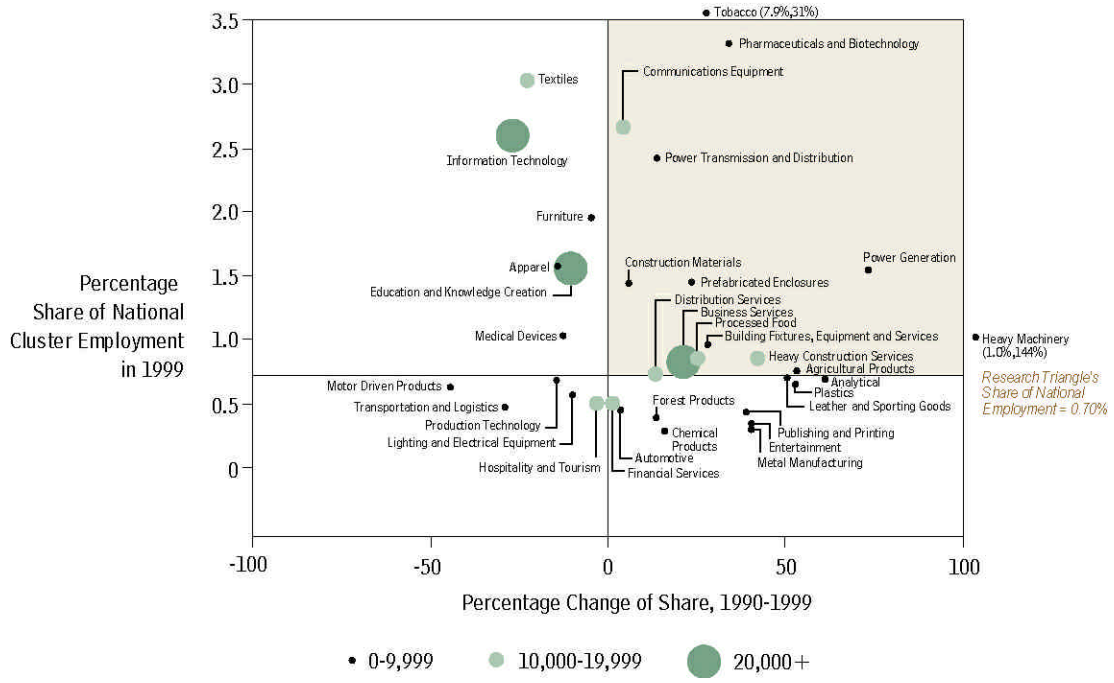
- **Establishment Formation.** The Research Triangle MSA's annual establishment growth rate of 3.4% between 1990 and 1999 was ahead of the national average of 1.3%. High growth rates in establishment formation indicate healthy later-stage innovation.
- **Venture Capital Investments.** Research Triangle MSA's venture capital funding per worker was $905 in 1999, compared to $266 for the nation. Research Triangle's venture capital growth rate between 1995 and 1999 was above the national average. However, the Research Triangle MSA lags other benchmark regions in venture capital investments, indicating that commercialization rates are not as strong as they could be.
- **Initial Public Offerings.** The Research Triangle MSA had 13 IPOs between 1996 and 1999, substantially lower than other benchmark regions. The Research Triangle's growth rate in IPOs during that time was 25.7%, more than Boston (17.7%), but less than Austin (36.8%) and San Jose (67.5%).
- **Fast Growth Firms.** The Research Triangle MSA had 1.1% of the firms on the Inc. 500 from 1991 and 2000, versus 0.6% of the total national employment. The Research Triangle's growth rate of Inc. 500 companies from 1991 to 2000 was 7.2%; above North Carolina's rate of 4.1%, California's rate of 1.8%, and Massachusetts' rate of 1.2%.

Composition of the Research Triangle Regional Economy

The Research Triangle has a relatively high percentage of employment in the high-wage traded clusters. Although the metro area has relatively few strong and growing clusters, the wider economic area has many. These strong clusters represent under-exploited opportunities for further economic development in the region.

- **Traded industry versus local industry employment.** The Research Triangle MSA's traded cluster employment as a percent of total employment decreased from 38.7% to 35.4% from 1990 to 1999, compared to a decrease for the United States from 34.0% to 31.9%. In 1999 the Research Triangle EA had 36.4% of its total employment in traded clusters, indicating a larger proportion of employment in traded industries if a wider geographic region it analyzed.
- **Good positions in numerous clusters.** The Research Triangle EA had 14 clusters that were relatively large and growing in 1999: agricultural products, building fixtures, equipment and services, business services, communications equipment, construction materials, heavy construction services, heavy machinery, distribution services, processed food, power generation, power transmission and distribution, pharmaceutical / biotechnology, and tobacco. The positions of these clusters is stronger in the Research Triangle EA than in the Research Triangle MSA, indicating the relevance of a broader economic development region. (See Exhibit 4 on the following page).

Exhibit 4: Specialization of the Economy, Research Triangle EA, Narrow Cluster Definition



Note: (y-axis, x-axis)
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

Innovative Capacity in the Research Triangle

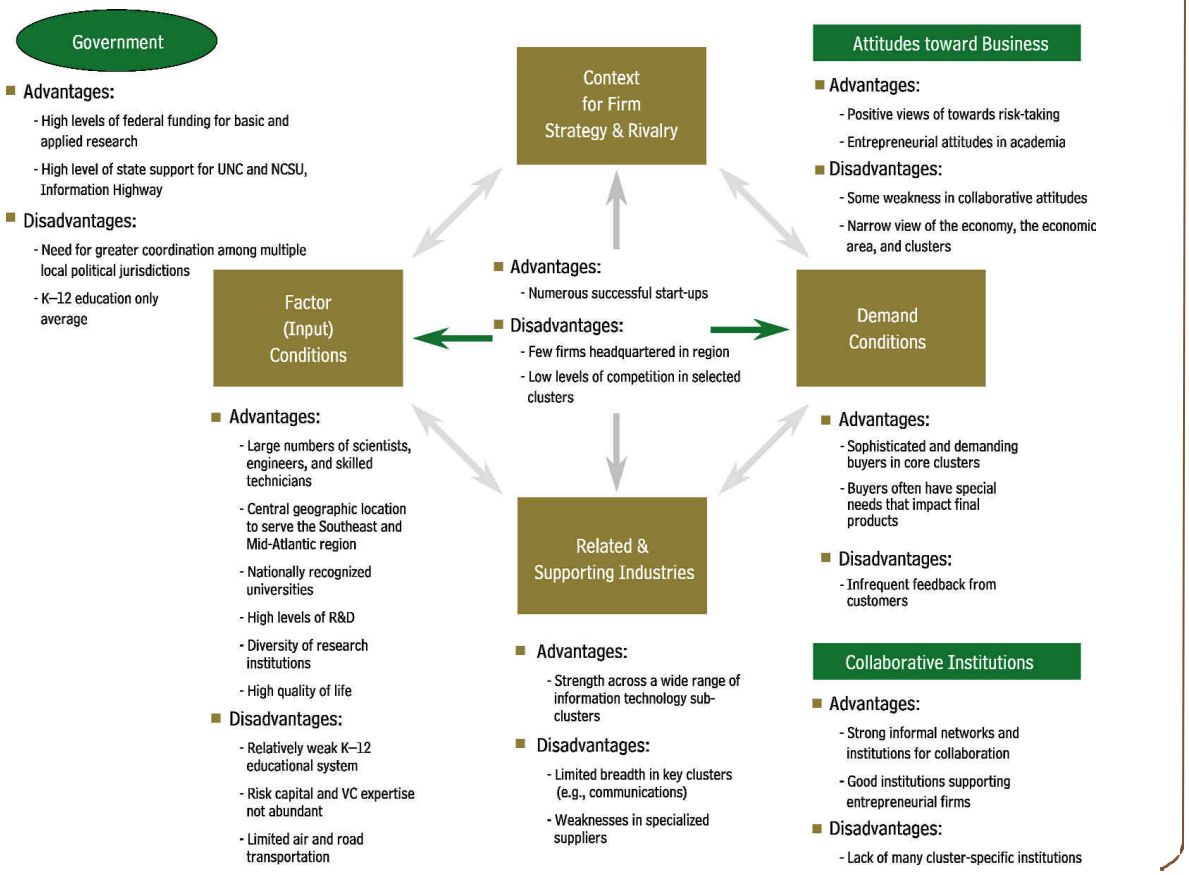
The Research Triangle's primary strengths are its superior research and training institutions, large pool of scientists and skilled workers. These assets largely explain the shift of employment into knowledge-intensive, service-oriented, traded clusters. Factors having little positive effect have been the local physical infrastructure, the commercialization of technology, the K-12 educational system, the focus on a limited array of clusters, the lack of large corporate headquarters, the relatively poor coordination among local jurisdictions, and the relatively low levels of collaboration within studied clusters.

- **Strong local universities and specialized assets.** The Research Triangle region has highly regarded educational, medical, and research institutions such as the University of North Carolina-Chapel Hill, Duke University, and North Carolina State University. The University of North Carolina-Chapel Hill and Duke University have been acting as anchor firms for the pharmaceutical / biotechnology clusters, while North Carolina State University is acting as an anchor firm in the communications equipment cluster. The diversity of these institutions has helped create healthy competition and speeds progress in the region.
- **Highly skilled work force.** Graduates from local colleges and universities provide a steady supply of specially trained scientists and engineers.
- **High levels of federal and state funding research and development.** The ability of the universities to act as anchor firms is due in part to high levels of federal funding, more than six times the national average.
- **Good quality of life.** Quality of life in the Research Triangle is considered a strength among residents due to good standard of living.

While fundamentally strong, the Research Triangle economy faces several challenges that, if unchecked, could undermine the region's historical bases of strength and recent diversified growth (see Exhibit 5). Some of the most important ones include:

- **Physical infrastructure is inadequate.** The Research Triangle needs to upgrade aspects of its physical infrastructure. Most critical will be increasing its roads and its air transport capabilities, both passenger and cargoincluding the number of key destinations and frequency of flights.
- **Weak technology commercialization structure.** Commercialization of basic research is a difficult and important ingredient for generating entrepreneurship. Although the Research Triangle region has high levels of innovation output, it could be higher still based on the levels of R&D investments per worker. Survey results indicate knowledge is not commercialized as effectively as it could be.
- **Focus on a limited array of clusters.** Diversification away from a limited array of clusters is critical given the region's over-dependence on a few, albeit strong, clusters. A downturn in one, as is currently the case in the communications equipment cluster, will lead to widespread effects on other clusters, including business services.
- **Weak coordination among local jurisdictions.** Solving many of these challenges (e.g., infrastructure, education, quality of life) will require effective government action and collaboration

Exhibit 5: Competitive Position of the Research Triangle Regional Economy



Source: Clusters of Innovation Initiative Regional Survey™ and Interviews

among communities. Currently, the Research Triangle region suffers from dispersed leadership spread among too many jurisdictions. As a result, there often times appears to be weak cooperation among urban and rural geographic communities.

- **Low collaboration within many clusters.** Better linkages within many clusters is required if the region is to benefit from the opportunities found at the intersection of clusters. Surveys indicate that companies and organizations within studied clusters have low levels of collaboration.

FINDINGS FROM THE PHARMACEUTICAL / BIOTECHNOLOGY CLUSTER

The pharmaceutical / biotechnology cluster in the Research Triangle is a leading national center of R&D, with many small large companies (e.g., GlaxoSmithKline, BASF, Bayer, and Novo Nordisk Biochem), and numerous research institutions (e.g., the University of California at Duke University Medical Center, the University of the Salk InstituteNorth Carolina-Chapel Hill, and the National Institute of Environmental Health Sciences).

Economic Performance

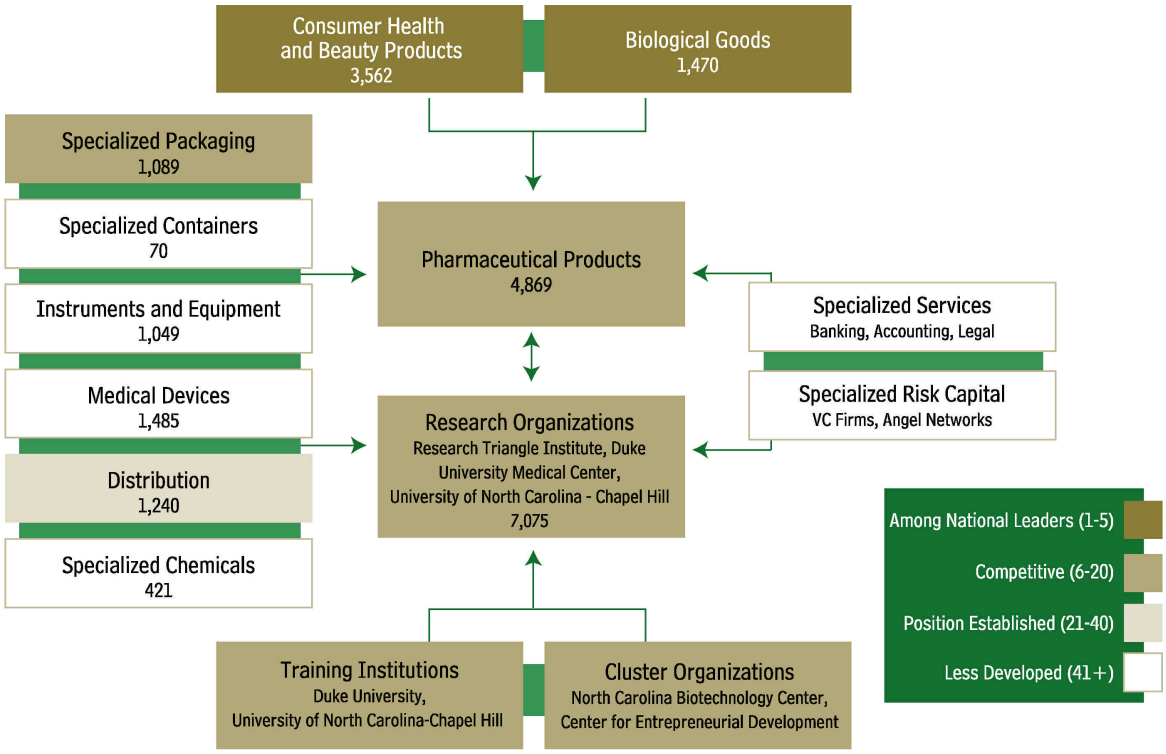
- **Employment.** In 1999, the Research Triangle EA (narrow cluster definition) had 8,501 pharmaceutical / biotechnology workers, making it the country's sixth largest cluster. From 1990 to 1999, the Research Triangle's pharmaceutical / biotechnology cluster had an annual growth rate of 4.0%, 11th fastest among the nation's 20 largest EAs. The pharmaceutical / biotechnology cluster has stronger positions as an EA than as an MSA.
- **Average Wages.** In 1999, average pay in the Research Triangle EA pharmaceutical / biotechnology cluster was $55,759, 3rd highest among the twenty largest EAs. Over the 1990 to 1999 period, the Research Triangle EA's pharmaceutical / biotechnology wage increased at an average annual rate of 6.8%, eighth highest among the nation's 20 largest regions.
- **Patent Registration.** In 1998, the Research Triangle EA pharmaceutical / biotechnology cluster registered 61 patents, making it the ninth highest patent total among the nation's 20 largest regions. That same year, the Research Triangle EA had 7.3 patents per 1,000 employees, making it the 13th highest among the 20 largest regions in the nation. The Research Triangle EA had the fifth fastest growth rate out of the 20 largest pharmaceutical / biotechnology clusters between 1990 and 1998.

Composition

The Research Triangle pharmaceutical / biotechnology cluster is focused on research, having one of the strongest critical masses of R&D and clinical testing institutions in the nation.

- The Research Triangle EA pharmaceutical / biotechnology cluster is among the national leaders in the consumer health and beauty products and biological goods subclusters.
- The cluster is competitive in the specialized packaging, pharmaceutical products, research organizations, training institutions, and cluster organizations subclusters. At an industry level, the region has a heavy concentration of employment in agricultural bioscience, bio manufacturing, contract research organizations, and bioinformatics and combinational chemistry. The cluster's weaknesses lie in the following subclusters: specialized containers, instruments and equipment, medical devices, specialized chemicals, specialized services, and specialized risk capital (see Exhibit 6 on following page).

Exhibit 6: Competitive Position, Pharmaceutical / Biotechnology Cluster, Research Triangle EA



Note: Employment numbers are given inside boxes were available
Source: Regional Survey Data, Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School and In-person Interviews

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.

Assets

- Workforce
  - Many trained and skilled workers.
  - Community College System offers specialized training and coursework.
- Research
  - Duke University Medical Center, University of North Carolina-Chapel Hill, North Carolina State University attract high levels of R&D investment and expertise.
  - Major research centers, including the National Institute of Environmental Health Sciences, US Environmental Protection Agency.
- Companies

  GlaxoSmithKline's U.S. headquarters acts as anchor to the cluster.

- Government
  - Federal government provides high levels of R&D investment.
  - Local government considered to be responsive to the cluster.

Challenges

- Competitive Context
  - Mild competition was recorded in the cluster.
  - No locally owned major pharmaceutical company.
- Cluster Linkages
  - Survey respondents reported that the cluster's sophisticated demand did not provide them with a competitive advantage.
  - Local companies received infrequent feedback from medical practitioners, which slows product improvements.
  - Cluster exhibits weak ties among cluster members.
  - Commercialization is less efficient than it could be.

FINDINGS FROM THE COMMUNICATIONS EQUIPMENT CLUSTER

The Research Triangle cluster grew in response to increasing demand for communications equipment technology. It is composed of many well-known companies focused on commercial applications. Anchored by IBM, Nortel Networks, and Cisco Systems, the Research Triangle has become a world leading center in telecommunications. In recent years, major international companies, such as Cisco, 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.

Economic Performance

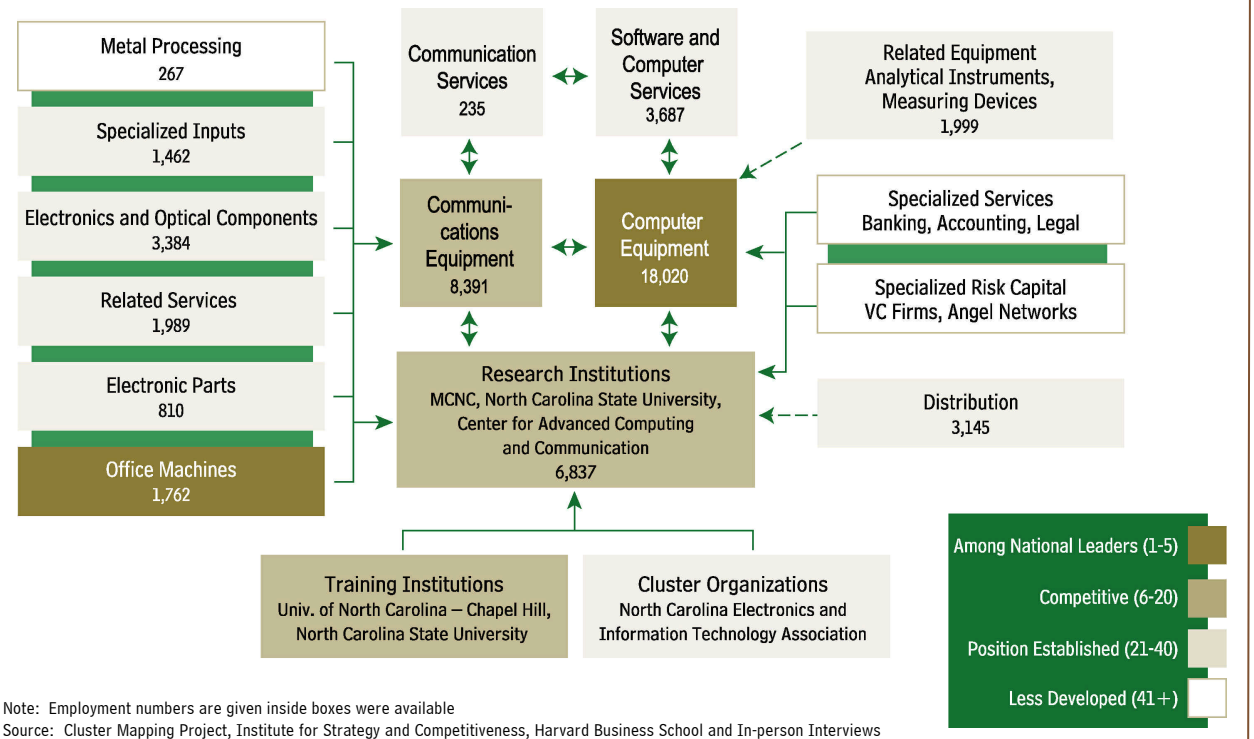
- **Employment**. In 1999, there were 11,616 employees in the Research Triangle EA communications equipment cluster (narrow cluster definition), making it the seventh largest cluster in the nation and the sixth fastest growing cluster among the nation's 20 largest communications equipment clusters.
- **Average Wages**. In 1999, the Research Triangle EA's average wage of $57,255 ranked it seventh among the nation's 20 largest national communications equipment regions.
- **Patent Registration**. In 1998, the Research Triangle EA (narrow cluster definition) communications equipment firms and institutions registered 141 patents, representing 1.77% of total United States communications equipment cluster patents. The Research Triangle ranks 13th in patents per employee as an EA, with 10.9 patents per 1000 employees and 18.9% annual growth rate from 1990 to 1999.

Composition

The Research Triangle communications equipment cluster includes leading firms in electronics, routing technology, and Internet communication devices as well as some communications software developers. Large employers include Cisco, Nortel, IBM, Ericsson, and Alcatel. Fast growing small firms include Caspian Networks, a provider of optical IP switches, and Redback Networks, a leading designer of data communications equipment.

- The Research Triangle EA communications equipment cluster is among the national leaders in the computer equipment and office machines subclusters (see Exhibit 7).
- The cluster is competitive in the communications equipment and research and training institutions subclusters. At an industry level, the region has a heavy concentration of employment in electronics, routing technology, and Internet communication devices as well as some communications software developers. The cluster's weaknesses lie in the following subclusters: metal processing, specialized services, and specialized risk capital.

Exhibit 7: Competitive Position, Communications Equipment Cluster, Research Triangle EA



Note: Employment numbers are given inside boxes were available
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School and In-person Interviews

Innovative Capacity

Our analysis indicates a strong innovation environment has emerged, based primarily on research and development by established communications equipment multinationals, and a highly trained labor force, and nascent university-business linkages.

Assets

- Workforce
  - Relatively large pool of communications-related trained and skilled workers.
  - Community College System offers specialized training and coursework.
- Research
  - University of North Carolina-Chapel Hill and North Carolina State University attract high levels of R&D investment and expertise.
  - Major research centers, including the Microelectronics Center of North Carolina and the Center for Advanced Computing and Communication.
- Companies
  - IBM and Cisco's home base act as anchors to the cluster.
  - Strong company presence in most communications equipment sub-clusters.
- Competitive Context
  - Sale of Cronos to JDUniphase points to prior success in development and marketing efforts by institutions of collaboration.
  - The North Carolina Information Highway project demands the latest technologies.

Challenges

- Workforce
  - Insufficient supply of marketing and managerial talent for the cluster's companies.
- Cluster Linkages
  - Under utilization of non-commercial research facilities.
  - Commercialization has proven to be difficult.
  - Sporadic cooperation among firms to jointly develop technology.
  - Insufficient frequency of contact with suppliers on innovation.
  - North Carolina Telecommunications Association is not yet well established as an effective regional organization.
- Companies
  - No locally owned major communications equipment company.
- Competitive Context
  - Many specialized suppliers are not readily available inside the region.
  - Local demand conditions do not confer an advantage on the cluster.
- Government
  - State and local government considered to be generally unresponsive to the cluster.

FINDINGS FROM THE BRIEF CASE STUDIES ON THE TEXTILES, PLASTICS, AND CHEMICALS CLUSTERS

The textiles, plastics, and chemicals clusters represent a much smaller, but equally telling story of the Research Triangle economy. The history of North Carolina is inextricably tied to the development of the textiles, chemicals, and plastics clusters. Whether it is the legacy inherited by the textiles cluster, or the more recent bonds between the chemicals, plastics (and pharmaceutical) clusters, these small (under 6,000 employees in each as an MSA, and under 17,000 in each as an EA) clusters represent important suppliers of specialized inputs, related industries, and various related industry organizations, educational institutions, and government agencies.

Economic Performance

- Added together, these three clusters amount to almost 6,000 employees in the MSA and 17,000 employees in the EA.
- These are highly innovative clusters that exhibit high patenting rates.
  - The chemicals cluster had a patents per employee indexed to the national average of 3.07 and the highest patents per capita among the nation's largest twenty clusters.
  - The plastics cluster had a patents per employee indexed to the national average of 1.18 and the 6th highest patents per capita among the nation's largest twenty clusters.
  - The textiles cluster had the 8th highest patents per capita average among the nation's largest twenty clusters.

Composition

Major textile companies such as Beaunit and Hercules, and diversified chemical firms such as Chemstrand, built R&D facilities in the Research Triangle Park's "first wave." Additional, nationally recognized institutions for collaboration in textiles, chemicals and plastics clusters were subsequently established or attracted to the region. These three clusters remain highly specialized and innovative, providing excellent linkages to other clusters, world-class scientific and technical know-how, and high patent rates.

- While certainly an "old" cluster, the Research Triangle's textile cluster has linkages with other clusters. Textiles has especially strong sub-clusters in fabric mills, yarn and thread mills, specialty fabric mills, specialty components, finishing mills, wool mills, textile machinery, fibers, and carpets and rugs.
- Plastics cluster has the highest growth rate among the twenty largest plastics clusters and strengths in several sub-clusters, including related plastic products and plastic products.
- Chemicals had the highest growth rate among the largest twenty clusters and strengths in several sub-clusters, including related products, diagnostic and biological products, and instruments.

Innovative Capacity

Assets

- Research
  - North Carolina State University has several major specialized research centers, including the School of Textiles' Textile Protection and Comfort Research Center and the Nonwovens Cooperative Research Center.

- Chemical Industry Institute of Toxicology is a specialized research center for the chemical's cluster.
- The Research Triangle Institute's Analytical and Chemical Sciences branch is a major specialized research center.

· Cluster Linkages
- American Association of Textile Chemists and Colorists is a key cluster-specific institution for collaboration.
- International Union of Pure and Applied Chemistry is a major international institution for collaboration in the chemicals cluster.

Challenges

· Cluster Linkages
- Major centers of innovation and institutions for collaboration in these three clusters are not being incorporated effectively into regional development strategies.
- Opportunities at the intersection of these three clusters are not being developed with other, more developed clusters.

· Companies
- There is no locally owned major textiles, plastics, or chemical company.

SUSTAINING COMPETITIVE ADVANTAGE: LESSONS, CHALLENGES, AND OPPORTUNITIES

The current success of the Research Triangle economy grows out of a decades-long process. It began with investments in education and the development of a strong core of world-class research centers military and then bio-science research institutions. These institutions, which over the years have enjoyed considerable federal and state funding, are the taproots of the region's economic growth. The Research Triangle 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 also been able to recruit well-known corporations to the region, mainly in the pharmaceutical / biotechnology and communications equipment industries. These assets helped the region emerge from the severe economic challenge posed by defense cutbacks at the beginning of the 1990s. Today, the Research Triangle's economy is growing and contains a more diverse set of industries than was the case four decades ago, when the economy was heavily dependent on agriculture and textiles.

Accomplishments

· A small group of leaders was able to initiate economic development by investing in education, developing world-class research universities and research centers, and establishing the Research Triangle Park.
· The Research Triangle metro area was able to recruit major corporations in the pharmaceutical / biotechnology and communications equipment clusters.
· The region developed the capacity to create new firms and industries from local knowledge centers.
· Local leaders built effective institutions for collaboration.

Assets

These accomplishments have left the Research Triangle metro area with a number of assets:

- Research Triangle Park and specialized research centers across different clusters.
- Positions in fast-growing industry clusters.
- Competitive cost position versus other technology centers.
- Good workforce training infrastructure and leading research universities
- High levels of federal and state R&D investments
- Good standard of living and relatively low unemployment, which have led to a high quality of life.

Lessons

The Research Triangle's accomplishments, and the processes by which the region has encouraged the development of the economy, offer numerous lessons for how other regions can emulate its success.

- **Universities and specialized research centers were the driving force of innovation in the region.** Although companies and individuals do create a large number of innovations, universities and research centers institutionalize entrepreneurship and ensure a steady flow of innovation. Research Triangle's specialized assets contributed to the development of industry clusters and innovation. These assets include the Research Triangle Park, Duke University, University of North Carolina-Chapel Hill, and North Carolina State University.
- **Diversity of research institutions creates healthy competition and speeds progress.** Such research institutions as the Research Triangle Institute, the Duke University Medical Center, the Center for Advanced Computing and Communication, the National Institute of Environmental Health Sciences, and the US Environmental Protection Agency enable companies to choose from a diverse set of models of how research institutions interact with companies in the region.
- **Specialized talent and training are more important than abundant, low-wage labor.** In interview after interview, executives reported that they moved operations to the Research Triangle in large part because of the highly talented, specialized, and often expensive local talent pool.
- **Proximity fosters productivity and innovation.** Close proximity of such research institutions as the National Institute of Health and Environmental Sciences, the US Environmental Protection Agency, and the Research Triangle Institute encouraged collaboration and innovation.
- **Institutions for collaboration lead to innovation and play an important role in building the regional economy.** Institutions for collaboration enable economic upgrading and cluster development to occur faster. The Research Triangle has a number of such institutions, including the Research Triangle Foundation, the Research Triangle Regional Partnership, and the Greater Triangle Regional Council.
- **Strong leadership is a necessary part of any successful economic development strategy.** Strong leadership committed to regional economic development is needed to ensure that companies, knowledge centers, governments, and collaborative institutions contribute to their full potential. Strong leadership is a necessary part of the region's successful economic development strategy. Strong leadership committed to regional economic development is needed to ensure that companies,

knowledge centers, governments, and collaborative institutions contribute to their full potential. Several leaders throughout the last four decades, including former Governors Hodges, Sanford, and Hunt, were instrumental in the Research Triangle's success.

- **Building strong regional economies takes decades.** It took 20 years to build a large corporate R&D presence in the Research Triangle, and another 20 to see significant economic consequences flow from it.
- **Government can have a significant influence on the business environment, both positively and negatively.** In 1958, with the economy of North Carolina still dependent on maturing industries such as tobacco and textiles, the state's government and business leaders, including North Carolina Governor Luther Hodges, set out to foster economic development through far-sighted investments in universities, research centers, and infrastructure.
- **Higher levels of innovation output lead to higher levels of prosperity.** In the 1950s, North Carolina had an abundance of low-cost labor, but dim economic prospects. Four decades later, Research Triangle has a growing, prosperous economy that is clearly the result of the successful innovation. Innovation made the difference.

Challenges

Despite its creditable accomplishments, Research Triangle faces several challenges, which it needs to meet in order to achieve the next level of regional success. Its core challenges are to improve its physical and educational infrastructure, buttress its technology commercialization capabilities, reinforce and broaden its economic structure, and advance collaboration in the region.

- **Physical infrastructure is inadequate.** The Research Triangle needs to upgrade aspects of its physical infrastructure. Most critical will be increasing its roads and its air transport capabilities, both passenger and cargoincluding the number of key destinations and frequency of flights.
- **K-12 Education is lagging.** Interviewees consistently report that they are not satisfied with the quality of K-12 education. Not only does this restrict the supply of home-grown talent, it also makes it more difficult to attract companies and workers.
- **Weak technology commercialization structure.** Commercialization of basic research is a difficult and important ingredient for generating entrepreneurship. Although the Research Triangle region has high levels of innovation output, it could be higher still based on the levels of R&D investments per worker. Survey results indicate knowledge is not commercialized as effectively as it could be.
- **Historical focus on a limited array of clusters.** Diversification away from a limited array of clusters is critical given the region's over-dependence on a few, albeit strong, clusters. A downturn in one, as is currently the case in the communications equipment cluster, will lead to widespread effects on other clusters, including business services.
- **Lack of large corporate headquarters in the region.** While it is true that several successful companies have spun-out of GlaxoSmithKline, IBM, Cisco, and Nortel, there are still no locally owned major pharmaceutical / biotechnology or communications equipment company. Overall community-sponsorship and leadership efforts suffer as a result.
- **Weak collaboration among communities.** Solving many of these challenges (e.g., infrastructure, education, quality of life) will require effective government action and collaboration among com-

munities. Currently, the Research Triangle region suffers from dispersed leadership spread among too many jurisdictions. As a result, there oftentimes appears to be weak cooperation among urban and rural geographic communities.

- **Low collaboration within many clusters.** Better linkages within many clusters is required if the region is to benefit from the opportunities found at the intersection of clusters. Surveys indicate that companies in several clusters have low levels of collaborative relationships with other clusters.

The Need for New Directions

The Research Triangle's success made it a highly innovative and competitive region in the United States. However, competition is dynamic, and to remain competitive the Research Triangle must be dynamic as well. Our analysis identifies several themes by which the Research Triangle can transition from a fast-growing economy to a diversified, mature, and strongly performing economy.

From the Research Triangle Park to a new strategy for the region. The original strategy of creating Research Triangle Park, and using the assets in local universities to help develop the regional economy has been a tremendous success. Rather than lose the region's most talented workers, the strategy helped retain them, and attract outsiders. Successful companies were recruited, and local companies started and enjoyed great success.

The success of this strategy, however, has created problems that cannot be solved by the current course. Growth is leading to more traffic, stressing the local school systems, increasing the cost of living; amenities that enabled the old strategy to succeed. Communities within the Research Triangle area, no longer galvanized by a common economic challenge, do not collaborate as well as they have in the past. Prosperity is also narrowly focused in a few local clusters and in the metro area, which has led to some resentment in other communities. Interviewees report a sense of drift among the local leadership. A new economic strategy is needed to reenergize the community, increase collaboration, and solve ongoing challenges.

From "high-tech" clusters to broader innovation economy. Clusters in the Research Triangle such as pharmaceutical / biotechnology, information technology, and communications equipment have received considerable attention and support from universities, economic development organizations, and various levels of government, and have succeeded in part because they got that support. These "high-tech" clusters are not, however, the main employers in the region. Clusters such as business services, education and knowledge creation, heavy construction services, distribution services, and financial services have created the most jobs in the region from 1990 to 1999. The next step in the Research Triangle's economic development is to support innovation across **all** clusters. These include those most closely aligned with these developed clusters, including: analytical instruments, medical devices, plastics, chemicals, and textiles.

From Metro Area to Economic Area. The Research Triangle leaders have focused on a narrow geographic area. The strategy of Research Triangle Park was to concentrate the scarce resources of local universities, and create a critical mass of institutions that would retain local workers and attract outside companies. The success of this strategy is very impressive.

Now, however, critical mass has been achieved, and indeed the concentration is creating problems (e.g., traffic, rising housing costs) that tend to undermine some of the historical strengths of the region. Moreover, areas of strength exist in a wider economic area. Relatively strong and growing clusters that

exist in the economic area, but not the metro area, include tobacco; power transportation and distribution; prefabricated enclosures; construction materials; heavy machinery; processed food, building fixtures, equipment, and services, and agricultural products. A new strategy should focus on using the knowledge assets concentrated near Research Triangle Park to boost innovation in relatively strong clusters located across a wider geographic area.

Opportunities

Research Triangle's opportunities include updating the original strategy behind the Research Triangle Park, establishing collaboration among a wide array of clusters, broadening the economy within many clusters and among communities, and attracting additional home bases to the region.

- **Improve collaboration in the "high-tech" clusters.** The Research Triangle has the opportunity to support and boost innovation across a large number of "high-tech" clusters. Many regions in the United States have only a few relatively concentrated "high-tech" clusters. The Research Triangle, however, has a large number of these high-paying clusters already present in the region, and should work to keep them.
- **Create a strategy to upgrade a wider array of clusters.** In addition to improving collaboration among these clusters, the region also needs to create a strategy to upgrade a wider array of clusters, some of which include: analytical instruments, medical devices, plastics, chemicals, and textiles.
- **Develop opportunities at the intersection of clusters.** There appears to be a number of under-exploited, crosscutting cluster opportunities in the region. Examples might be: environmental sciences, biotechnology and information technology, telecommunications and medicine, and biotechnology and agribusiness.
- **Integrate the economy with the broader region.** When devising economic development strategies, regions tend to focus on the immediate geographic area, usually a metropolitan statistical area. In some cases this is appropriate. In the case of the Research Triangle, however, a focus on the metro area neglects a wide range of assets that are readily accessible and part of the regional economy. On a wider scale, the Research Triangle should also develop closer ties with the financial services cluster and venture capital community in Charlotte, NC, as well as transportation and manufacturing linkages with Atlanta, GA by developing the distribution services cluster.
- **Attract and grow more home bases.** The Research Triangle community has a lot to offer corporations currently contemplating moving their corporate headquarters. A more concerted marketing and recruiting effort should be directed at insuring that at least one major corporation makes the region its home base.
- **Establish an overarching organization for economic development that helps coordinate and routinize the process.** Building a consensus behind a basic agenda, and a true commitment to the above attitudes is a difficult and ongoing process. Many regions achieve a shared vision primarily due to a crisis that galvanizes the community and spurs action. The Research Triangle region is not in a crisis, yet it seems clear that a new vision is needed. With that new vision must come a new way to formalize a process for working on these issues. An example from our research is the Massachusetts' Governor's Council on Economic Growth and Technology.

INTRODUCTION

Why Innovation Matters

During the 1990s, Americans found a way to do what seemed no longer possible — grow the economy, create jobs, and increase the standard of living, without driving up inflation. Much of the credit goes to the nation's ability to develop and commercialize new technology. The result: one of the most robust periods of economic expansion and prosperity of the past century.

Today, the nation is experiencing an economic downturn. As business and government leaders wrestle with this new context, most of the attention has been focused on monetary stimulus through lower interest rates and fiscal stimulus through lower tax rates and government spending. These are important tools to affect economic growth in the short run. However, neither addresses the fundamental causes of prosperity. Prosperity depends upon the productivity with which the United States economy uses labor and capital to produce goods and services. Productivity rises because of innovation. Moreover, sustained economic growth will require continued innovation at all levels of the United States economy, especially as we enter a new era when the workforce will be increasing more slowly.

While fiscal and monetary policies pump dollars into the economy to boost the level of activity, innovation infuses the economy with growth-incubating new ideas, new products and services, and new technologies. National policies and national investment choices have much to do with the growth and capacity of the American economy. For innovation, however, the real locus is at the regional level. The vitality of the United States economy then depends on creating innovation and competitiveness at the regional level.

ABOUT THE CLUSTERS OF INNOVATION INITIATIVE

The Clusters of Innovation Initiative offers a new way of thinking about economies that has begun to take hold as communities across the nation confront the successes of California's Silicon Valley, Massachusetts' Route 128, Austin, Texas, and other areas. In healthy regions, competitiveness and innovation are concentrated in clusters, or groups of interrelated firms and industries in which regions specialize. The nation's ability to produce high-value products and services that support high-wage jobs depends on the creation and strengthening of these regional hubs of competitiveness and innovation.

The Clusters of Innovation Initiative was launched to help meet this challenge. Under the leadership of Professor Michael Porter, Harvard University; Duane Ackerman, BellSouth Corporation; and a national steering committee— and supported by a partnership of Monitor Group and its affiliate, ontheFRONTIER, the Institute for Strategy and Competitiveness at Harvard Business School, and the Council on Competitiveness —the Initiative has worked to understand how regional economies develop, how clusters form and gain or lose competitiveness, and how innovative capacity is built. It offers recommendations for government, universities, the private sector, and other regional institutions. It aims to inform key decision makers across the country and provide a methodology for analysis that any region can utilize.

The Initiative studied five regions around the country: Atlanta, Pittsburgh, the Research Triangle, San Diego, and Wichita. These regions were selected to provide a diversity of size, geography, economic

maturity, and perceived economic success. The regions were similar enough to allow interesting comparisons, yet diverse enough to encompass a wide variety of challenges and opportunities in regional economic development.

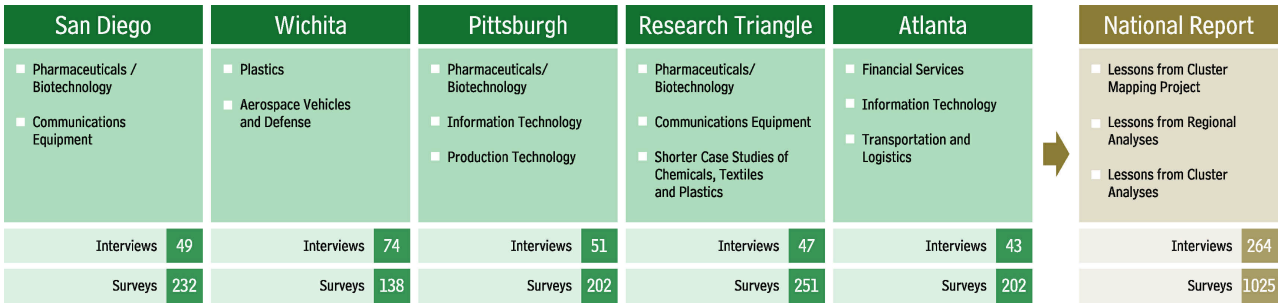
Data for the study were drawn from a number of sources, but the principal sources of data were the Cluster Mapping Project of the Institute for Strategy and Competitiveness, the Clusters of Innovation Initiative Regional Surveys, and in-depth interviews of business and government leaders in each region.

The Cluster Mapping Project is perhaps the most detailed data set related to economic composition and performance ever compiled. Comparing regional economies has historically been difficult because clusters have not been systematically defined and their incidence charted across all U.S. regions. The Cluster Mapping Project created a detailed statistical analysis using county-level business data, including detailed metrics on regional economic performance, and data defining 41 types of clusters (e.g., information technology, automotive, or business services) that are found in regions throughout the United States economy. The Cluster Mapping Data also mapped regional economies by cluster and constituent industry and compared regions to others on various indicators of economic vitality and future competitiveness. One of the goals of the Cluster Mapping Project is to disseminate this data widely to practitioners. (To access the data over the Internet, go to www.isc.hbs.edu.)

Monitor Group, its affiliate ontheFRONTIER, and staff from the Council on Competitiveness designed and implemented a far-reaching survey—the Clusters of Innovation Initiative Regional Survey"™ to study the business environment and cluster competitiveness in each region. More than 1,025 business and government leaders were surveyed and 264 in-depth interviews were conducted to determine the historical growth, recent performance, and composition of local economies. Fifteen clusters in the five regions were studied as well. In the Research Triangle region, 251 executives were surveyed, and another 47 were interviewed (see Exhibit 8 below).

While many projects around the United States and elsewhere have studied one particular region or one particular cluster or groups of clusters, the Clusters of Innovation Initiative is unique in its coverage of five regions and 15 individual clusters using a common methodology, individually and comparatively. The Cluster Mapping Data, surveys, and interviews provide a unique, outstanding information resource for these regions and the nation as a whole.

Exhibit 8: Regions, Clusters, and Unique Data



THE RESEARCH TRIANGLE

This report on the Research Triangle is the fourth of the five regional reports to be completed. The Research Triangle was chosen because of the way it emerged from its dependence on tobacco and textiles over four decades ago to become one of the country's fastest growing, diverse economic regions. Significant investment in research and development, important formal and informal connecting institutions between industry and academia and government, the recruitment of major corporations, and the vision, entrepreneurial spirit, and concerted action of business and government leaders enabled the Research Triangle to develop this economic diversity and attain competitive positions in advanced industry clusters such as information technology, communications equipment, and pharmaceutical / biotechnology.

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 economic competitiveness to the Research Triangle. It examines the overall performance and composition of the Research Triangle economy and describes how the Research Triangle transformed its economy over the course of the 20th century.
- **Section 4** examines the performance of important industry clusters — pharmaceutical / biotechnology and communications equipment, and to a lesser extent, chemicals, textiles, and plastics — in the region.
- **Section 5** draws from the regional and cluster-specific analyses to identify lessons that will inform the national Clusters of Innovation Initiative.

The Appendices include a definition of measurements used and detailed findings of the Clusters of Innovation Initiative Regional Survey."™

The development of specific recommendations and action plans is beyond the scope of this report. Nevertheless, it suggests several new strategic directions to pursue, challenges to overcome, and opportunities to seize in order for the Research Triangle 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 were presented at a National Clusters of Innovation Conference on December 13, 2001, in Washington, D.C. by the Council on Competitiveness. These findings provided the analytical basis for this conference and other initiatives to create and support high-performing industries and sustain our nation's competitiveness and prosperity.

1 ECONOMIC COMPETITIVENESS AND REGIONAL INNOVATIVE CAPACITY

DETERMINANTS OF REGIONAL PROSPERITY

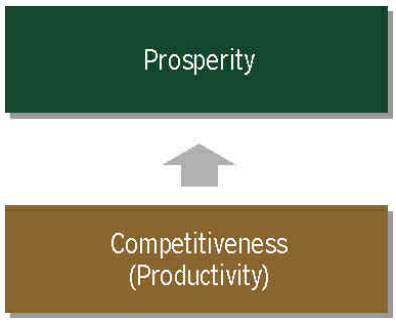
A nation's or region's standard of living is determined by the productivity of its economy. Productivity is measured by the value of goods and services produced per unit of the labor and capital. It sets the wages that can be sustained and the returns earned by investors—the two principal components of a nation's or region's per capita income. (See Exhibit 9 below)

Competitiveness, then, is defined by the level of productivity. Productivity determines 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.

Thinking on regional competitiveness is undergoing a significant transition. In many regions, efforts to enhance competitiveness were targeted on lowering the cost of inputs. The focus was on holding down wages, reducing taxes, and recruiting new companies using financial incentives. However, this model has been superseded for advanced economies and is ultimately self-defeating. Inputs such as cheap labor and natural resources are widely available. Prosperity comes from the ability to utilize a region's inputs more productively than other locations in producing goods and services. Low wages do not yield fundamental competitiveness, but they hold down the standard of living. Financial incentives are easily matched by competing regions and erode the tax base needed to invest in education and local infrastructure. In the new model, the only path to sustainable prosperity is to build a regional business environment and corporate capabilities that support high productivity.

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 the ability to create higher value products and services, as well on as improving the efficiency of processes. The central challenge in enhancing the prosperity of a region is to create the conditions for sustained productivity growth.

Exhibit 9: Prosperity and Productivity



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 because of 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 pre-existing 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 in a region will be equally successful, but success should be determined by the skills and entrepreneurship of the companies in a field rather than selective intervention by government.

The most important sources of regional prosperity are *created*, not inherited. Inherited competitive advantages such as natural resources, geographic location, or a supply of labor are becoming less important in determining prosperity. 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 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. Oil and gas are still produced in Texas, but Texas accounts for only a small and declining fraction of world production. However, Houston has become the world's center of technology and knowledge creation in oil and gas exploration and production, as well as the leading 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 even only physical products, but export 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. Local industries directly affect a region's impact on the standard of living because their productivity has a large influence on the local costs of living. However, local industries also affect the success of a region's industries competing with firms based elsewhere. 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 thus became a drag on the prosperity of the country despite the existence of some very productive exporting industries. Regional competitiveness, then, depends on ensuring that local companies in fields such as utilities, transportation, health care delivery, and other local services are competitive.

Innovation and the Growth of Productivity

Productivity today sets current competitiveness, but maintaining, much less increasing, a region's standard of living requires the steady growth of productivity. Especially in advanced, high-wage economies no region can maintain high wages, and hold its own in global markets, by producing standard products using standard methods because they will be imitated by other regions with lower wages.

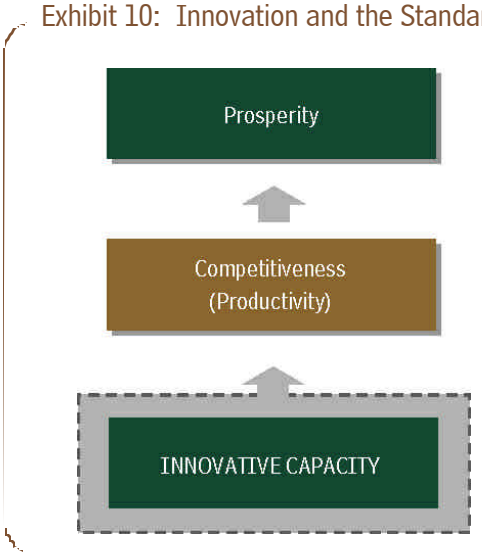
In advanced regions, prosperity rests heavily on the *capacity for continuous innovation*. A high level of productivity itself is not enough when developing countries and regions are improving their skills, and can

rapidly access modern technology. Advanced regions need to innovate to be able to produce products that lower wage regions cannot yet make, and to maintain the productivity advantage that supports their higher wages. (See Exhibit 10 below).

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 marketing, sales, services offered, and distribution; for example, innovation led to the revolution in the small-package delivery that occurred in the last 15 years and resulted in United States global preeminence in this industry.

There are no low-tech industries, only low-tech firms. Today, innovation can drive productivity improvement in virtually every industry. Although industry producing enabling technologies such as biotechnology, computers, software, and communications equipment and services have received much attention, opportunities to apply advanced technology are present in fields as disparate as textiles, machinery, and financial services. For example, the small-package delivery industry was transformed by advanced communication and information processing technologies that led to unheard-of efficiency and the ability to integrate with customers.

Exhibit 10: Innovation and the Standard of Living



In the modern economy, there are no "low-tech" industries, only low-technology companies that fail to incorporate new ideas and methods in their products and services. Innovation can upgrade the sophistication of competition and future productivity throughout a region's economy, not just in a few "high-tech" industries.

THE MICROECONOMIC FOUNDATIONS OF PRODUCTIVITY

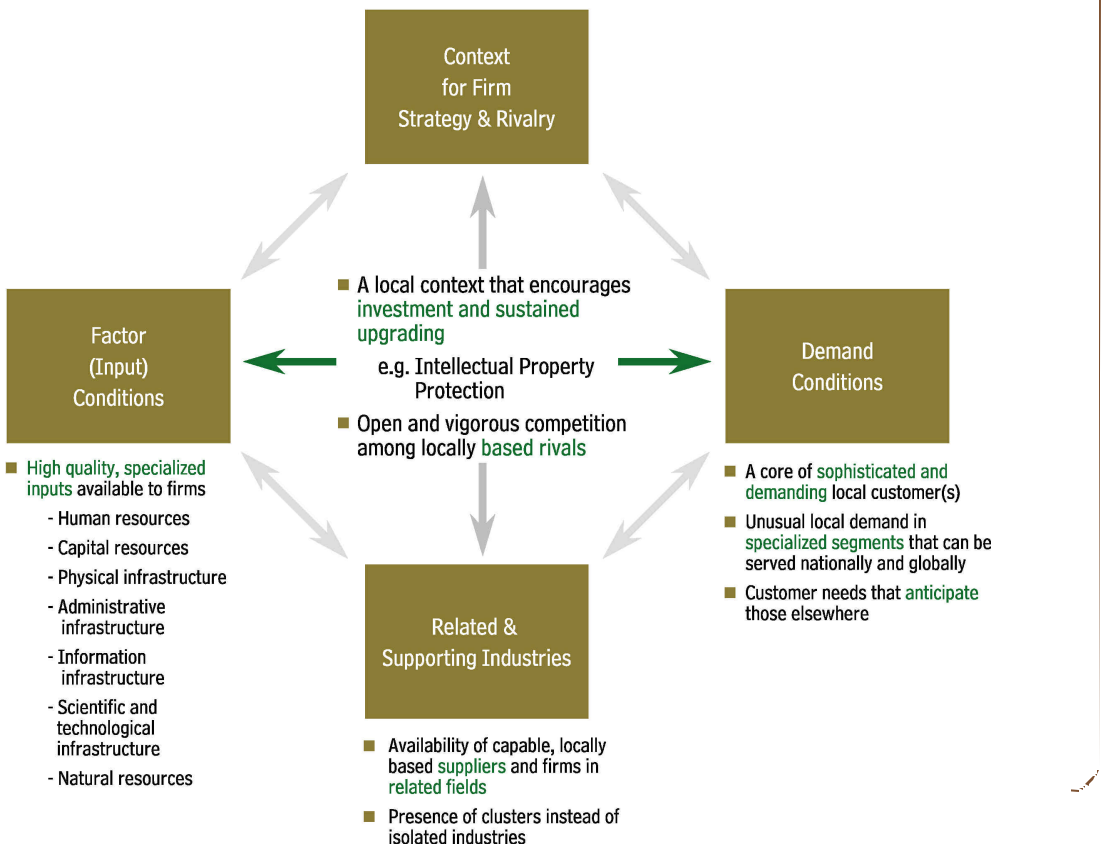
The productivity and innovativeness of a regional economy benefit from overall conditions such as a sound fiscal policy, an effective political decision making process, and sound legal institutions. However, broad regional attributes such as these are increasingly preconditions, not sources of competitive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

Prosperity in a region is actually created by the microeconomic foundations of competitiveness, rooted in the sophistication with which individuals, firms, and industries based there compete. This is what gives rise to productivity. Competitiveness requires ongoing improvement in the quality of corporate management and in 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. For example, the productivity of companies is affected by such things as the specific skills of employees they can attract, the efficiency of the local logistics and transportation system, and the extent to which local regulations impede productivity and innovation or encourage them.

Determinants of Regional Productivity

The quality of a region's business environment is embodied in four broad areas (see Exhibit 11 below). Each of them affects the level of productivity that can be achieved as well as the rate of innovation.[2]

Exhibit 11: Determinants of Regional Productivity



Factor conditions: Achieving high levels of productivity 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. More generic and basic factors such as high school graduates or the local transportation system are foundations that every region must have. Increasingly, competitiveness depends on the presence of advanced and more specialized factors.

Demand conditions: The quality of demand in a region 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.

Traditionally, regions and countries focused on the size of their local market. A large local market, it was believed, would allow local companies to exploit economies of scale and improve competitiveness. When productivity drives competitiveness and firms can easily access national and international markets, however, the quality rather than the quantity of local demand becomes important because it is crucial for innovation.

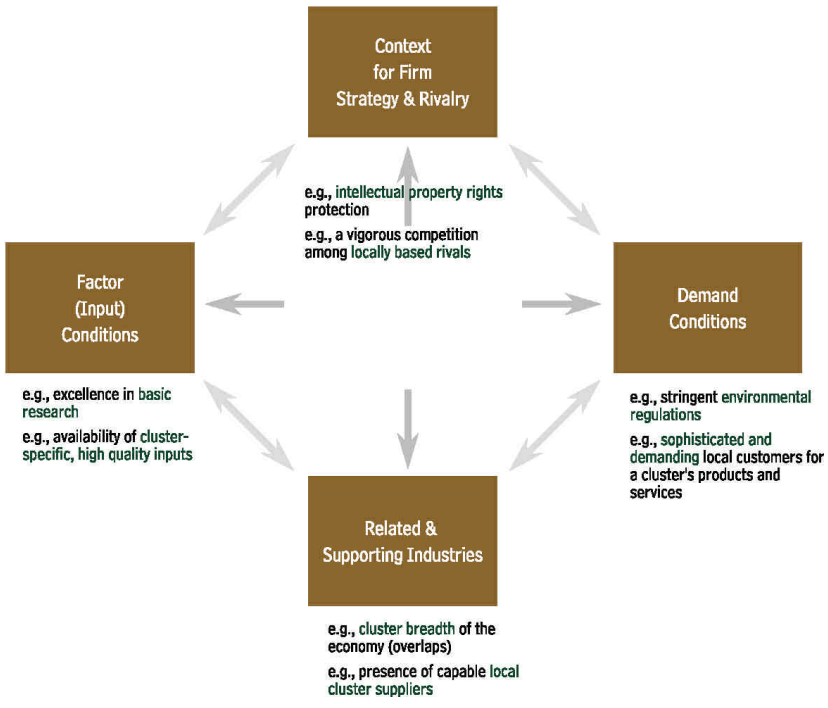
Context for firm strategy and rivalry: The rules, incentives, and pressures governing the competition in a region have a fundamental influence on productivity. Policies that encourage investment, protect intellectual property, and open the local market for trade, for example, foster productivity growth and competitiveness. Also exerting a strong influence on productivity are the presence of competing rivals in a region and the intensity of local industry.

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 local outsourcing. Traditionally, many regional development programs have focused on attracting individual companies and industries. However, isolated companies cannot be productive without the presence of related and supporting industries. Factor conditions: Achieving high levels of productivity 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.

These four areas of the regional business environment 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. Weaknesses in any part of the business environment, then, can erode the competitiveness of regions.

All parts of the business environment affect a region's productivity and competitiveness. A subset of the overall environment has particular importance in determining a region's capacity for innovation (see Exhibit 12).

Exhibit 12: Innovation and the Microeconomic Business Environment

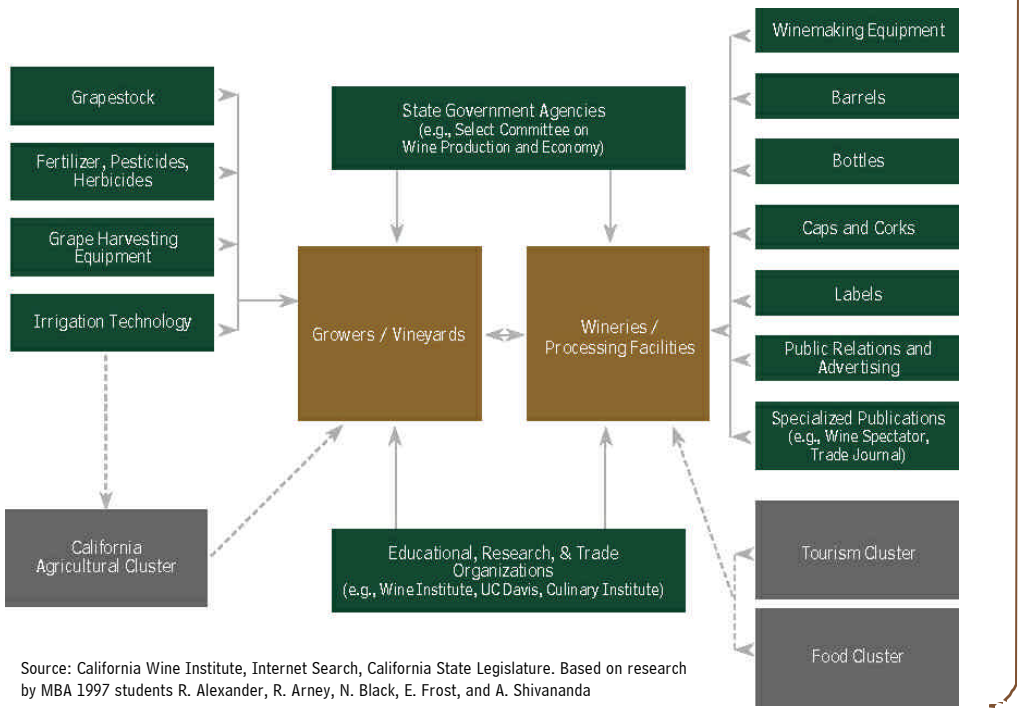


Clusters and Productivity

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, logistics, and personal interaction are possible. Clusters are normally concentrated in regions and sometimes in a single town.

Clusters cut across traditional industry classifications. Clusters take various forms depending on their state of development. Well-developed clusters, however, normally include end-product or service companies; suppliers of specialized inputs, components, machinery, and specialized services; financial institutions; and firms in related industries. Clusters also often include firms in downstream or customer industries; producers of complementary products; specialized infrastructure providers; government, universities, and other institutions providing specialized training, education, information, research, and technical support; and standard setting agencies. Finally, many clusters include trade associations and other private sector collective bodies that support cluster members (see Exhibit 13).

Exhibit 13: The California Wine Cluster



Source: 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 technical expertise in a demanding competitive environment. Extensive market, technical, and other specialized information accumulate within a regional cluster. Specialized inputs can be assembled, and relationships are forged among cluster participants. Firms can access trained people and technology at much lower cost than developing it internally. The presence of a full range of knowledge, inputs, machinery, and services makes experimentation easier and promotes greater efficiency and flexibility than vertical integration of relationships with distant suppliers.

Second, clusters *foster innovation* by increasing the dynamic effects of the business environment.

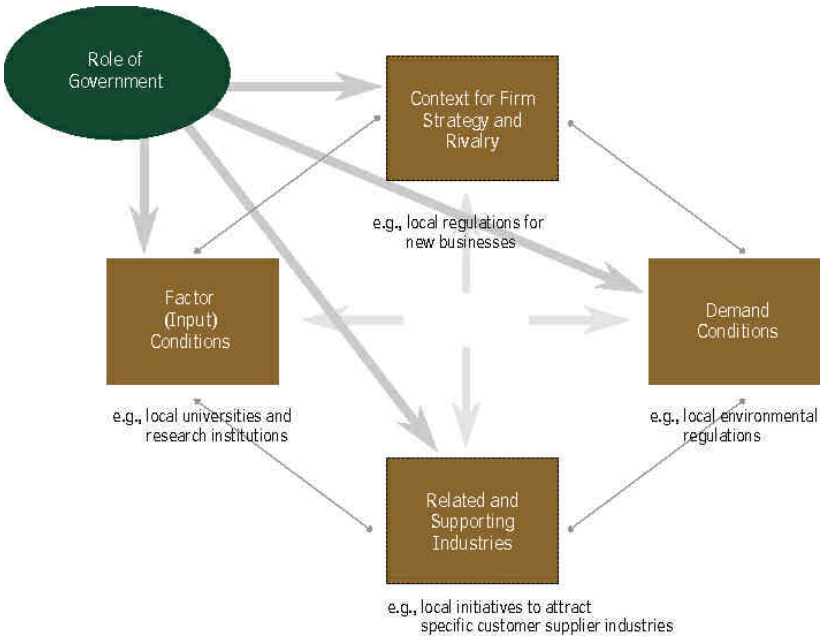
Third, clusters facilitate the commercialization of innovation by easing the creation of new firms via startups, spin-offs and business lines of established firms. Establishing a new business in a cluster location is easier than elsewhere because all the needed inputs are locally available there, as are cluster awareness and expertise among capital providers such as banks and venture capitalists. The creation of new firms and business units reinforces productivity and encourages innovation.

Clusters draw on both general and cluster-specific aspects of the business environment. Clusters benefit from general national and regional attributes such as intellectual property laws, transportation infrastructure, and the education system. However, the competitiveness of a cluster, and its uniqueness, usually owes much to the specialized circumstances of the location for the particular cluster.

Other Influences on the Business Environment

Government: Government affects competitiveness through its influence on the business environment (see Exhibit 14 below). Government at all levels influences (positively or negatively) the business environment and the productivity of clusters. Government is not monolithic, and its influence occurs through a myriad of distinct departments and entities. While the federal government is often seen as having the greatest impact on competitiveness, policies at the regional and even local level are often equally if not more important. Each level of government affects various aspects of the business environment, and the policies of different units of government can frequently be conflicting.

Exhibit 14: Government's Impact on Regional Productivity



Government plays five distinct types of roles in competitiveness, some of which are often overlooked. It establishes a stable macroeconomic, political, and legal environment; improves the availability, quality, and efficiency of generalized inputs, infrastructure, and institutions, such as roads and schools; sets the overall rules and incentives governing competition such as investment incentives, antitrust laws, and intellectual property protection rules; facilitates cluster development and upgrading; and establishes and participates in an ongoing process for defining regional competitive priorities and implementing them across constituencies.

Most governments realize the first three roles. Few governments have effectively addressed the fourth and fifth roles and the second role as far as basic factor conditions are concerned. Advanced factor conditions, incentives, and the institutions and processes of cluster development have become much more important roles of government.

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 companies can operate. Many U.S. regions, for example, have traditionally sought to attract industry through tax incentives and driving down the cost of doing business in terms of payroll taxes, unemployment insurance, utilities, and the like. This approach may be necessary in uncompetitive regions, but it is ultimately self-limiting. Pushing down costs can reduce the revenue necessary to improve education, infrastructure, and services. Improving the productivity of the region, and boosting its innovative capacity, is more effective in increasing the standard of living in the long run.

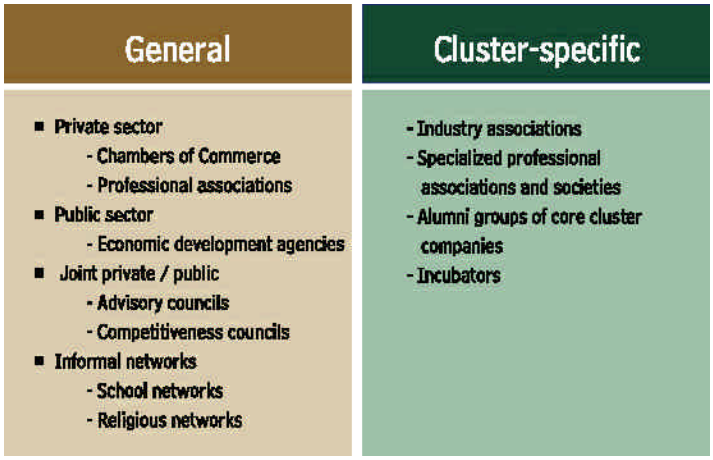
The traditional separation between the public and private sector no longer applies. In the old model, the public sector was to provide the infrastructure while the private sector focused on competition. In the new model, the level of co-dependence of public and private sector has hugely increased: The public sector needs to set policies in close interaction with the private sector while the private sector derives key sources of its competitive success from outside the firm. The new model also includes a much broader set of institutions such as universities, regulatory bodies, and trade associations.

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 kinds of local coordination and collaboration that can improve the business environment in the overall economy or in a cluster. Institutions for collaboration, then, create and amplify the arrows and feedback loops.

Institutions for collaboration take various forms (see Exhibit 15 on the following page). Some are economy-wide or address broad sectors, while others are cluster-specific. Institutions for collaboration affect productivity and innovation in a number of ways. First, they create relationships and enhance the level of trust in these relationships. Second, they facilitate the organization of collective activity. Third, they encourage the definition of common standards, rules, and norms that stimulate competition or boost productivity. Finally, they can be mechanisms to develop a common economic or cluster agenda.

Exhibit 15: Examples of Institutions for Collaboration



Economic Attitudes, Values, and Beliefs

A final influence on regional competitiveness and innovative capacity is more intangible. Attitudes, values, and beliefs about the economy—which are often termed "culture"—bear on the behavior and aspirations of individuals, firms, and other institutions in a region. Of particular importance in an advanced economy like the United States are beliefs about the importance of entrepreneurship, attitudes toward collaboration, and civic mindedness.

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 independently of the private sector. Today, however, innovation depends on much greater company-university interchange. Companies depend not only on internal R&D but also on 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 three broad types of firms and industries. Each is important to a region's prosperity, but in different ways.

The first type is industries that compete across locations. In the United States, this competition often occurs between domestic regions but may also include foreign locations. Grouped into clusters, this type of industries is called "traded."

The second type is industries that are resource-driven.

The third type is industries that compete only within their region. This type of industries is called "local." Local industries are intrinsically tied to the traded industries located in their region: they directly serve the needs of the traded industries as suppliers and service providers, and they indirectly depend on the success of the traded industries through their influence on final consumer demand.

Types of Clusters

Traded clusters have a disproportionate influence on regional prosperity and economic growth. Traded industries can, in principle, be located anywhere. But similar traded industries tend to concentrate in specific locations. Because they grow beyond the size and the needs of the local market, they can become much more sophisticated and productive. Their high productivity can support high wages that support the prosperity of their employees but also support the prosperity of others through the consumer demand they create.

Resource clusters can support high wages but have limited scope in advanced economies. Resource-driven industries also compete across regions but their location is tied to local resources. Their performance is much more dependent on the way the industries use technology and innovative processes than on the direct value of the natural resources they process. For example, despite virtually identical natural conditions, the pulp and paper industries in Finland with their sophisticated use of technology achieve much higher productivity than their less advanced competitors in Canada.

Local clusters account for the majority of employment in regional economies. Because local industries serve only the local market and most are services, they have more limited opportunities for productivity growth. This means that local industries tend to account for an increasing share of regional employment.

Traded industries seem to be more dispersed than they really are because most firms establish distribution centers, sales offices, service facilities, and other supporting functions in almost every region. The locations where truly competitive firms are based are usually limited in number.

The traded economy is specialized by cluster. Clusters are geographically proximate groups of interconnected companies and associated institutions in a particular field, linked by commonalities and complementarities. Regional economies can be profiled on the mix of clusters present. It is on the level of individual clusters that regional economies specialize.

Specialization in a series of strong clusters with a significant national position enhances a region's performance. Clusters that can attain the critical mass gain productivity and innovative benefits. A region which depends heavily on just one or very few clusters for much of employment, however, can be exposed to shocks and instability both in those clusters and in the local industries which depend on them. For example, the recent downturn in the information technology cluster has been especially detrimental to Singapore, a city-state with an economy heavily dominated by this cluster.

Traded clusters drive regional prosperity. While local clusters account for roughly two-thirds of employment in an average region, traded clusters heavily influence the prosperity and growth of a region. 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 16 shows the average composition of regional economies in the United States. Traded clusters accounted for 32.1% of total employment in 1999, with an average wage in 1999 of $41,678. Local clusters account for 67.1% of employment in 1999 with an average wage of $26,049. The average wages of traded clusters have grown at a compound annual growth rate of 5.0% between 1993 and 1999, compared to 3.8% for local clusters.

The higher wages of traded clusters reflect their much higher productivity, shown in Exhibit 16. 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.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 16: Composition of Regional Economies, United States

	Traded Clusters	Local Clusters	Natural Resource-Driven Industries
Share of Employment	32.1%	67.1%	0.8%
Employment Growth 1993 to 1998	2.5%	2.8%	0.1%
Average Wage	$41,678	$26,049	$31,264
Relative Wage	134.0	83.8	100.5
Wage Growth	5.0%	3.8%	2.5%
Relative Productivity	144.1	79.3	139.5
Patents per 10,000 Employees	20.48	1.38	6.40
Number of SIC Industries	592	241	46

Note: 1999 Data, except relative productivity which is 1997 data, Patents data which is 1998 data
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

REGIONAL STUDY METHODOLOGY 2

The Clusters of Innovation Project examines five regions: San Diego, Atlanta, Pittsburgh, the Research Triangle, and Wichita. For the purposes of this study, a region is defined as a metropolitan statistical area (MSA) using United States Department of Commerce boundaries, and, in some cases, the Economic Area (EA).[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 evolution and composition of the regional economy
- Assessment of the region's business and innovation environment
- The competitiveness of selected regional clusters
- Findings and 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, PwC Money Tree, and the Inc. 500 List.

The principal source of quantitative data on the composition and performance of the overall economic and specific clusters was the Cluster Mapping Project of the Institute for Strategy and Competitiveness at Harvard Business School. The Cluster Mapping Project (CMP) has compiled in-depth data on employment, wages, establishments, and patenting activity by cluster at the county 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 survey was conducted of business, government, and non-profit leaders in the region. (The full survey is included as Appendix 2). Surveys were completed by 251 executives at companies and institutions throughout the region. Of the total, 125 were companies from the cluster representatives, and 126 were from regional institutions of collaboration and other non-cluster organizations (e.g., venture capital firms, or banks).

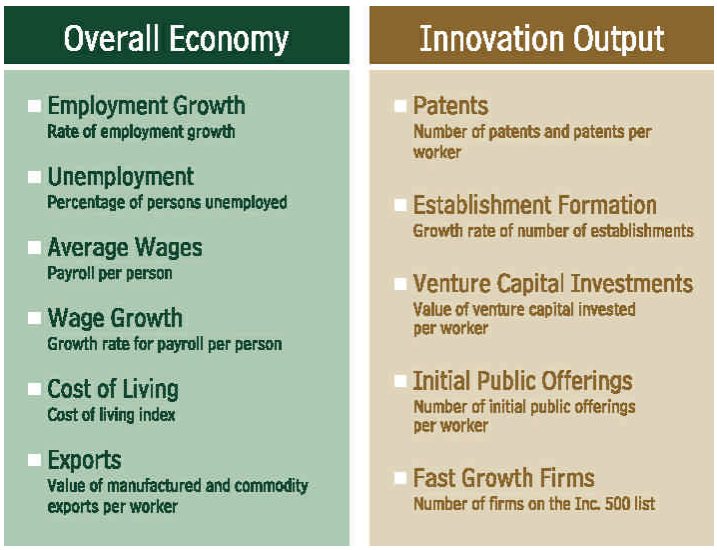
We also conducted 47 in-depth interviews with a selection of Research Triangle leaders. Of these, 17 were with business executives in the pharmaceutical / biotechnology and communications equipment cluster, and 30 were executives in other clusters, academia, government, or institutions for collaboration.

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, cost of living, and exports. To assess potential future competitiveness, we examined measures of innovative output and entrepreneurship including patents, establishment formation, 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 17).

We compared the performance of the Research Triangle economy to the national economy as a whole, as well as to other technology-intensive regions.

Exhibit 17: Economic Performance Indicators, Research Triangle



THE COMPOSITION AND EVOLUTION OF THE REGIONAL ECONOMY

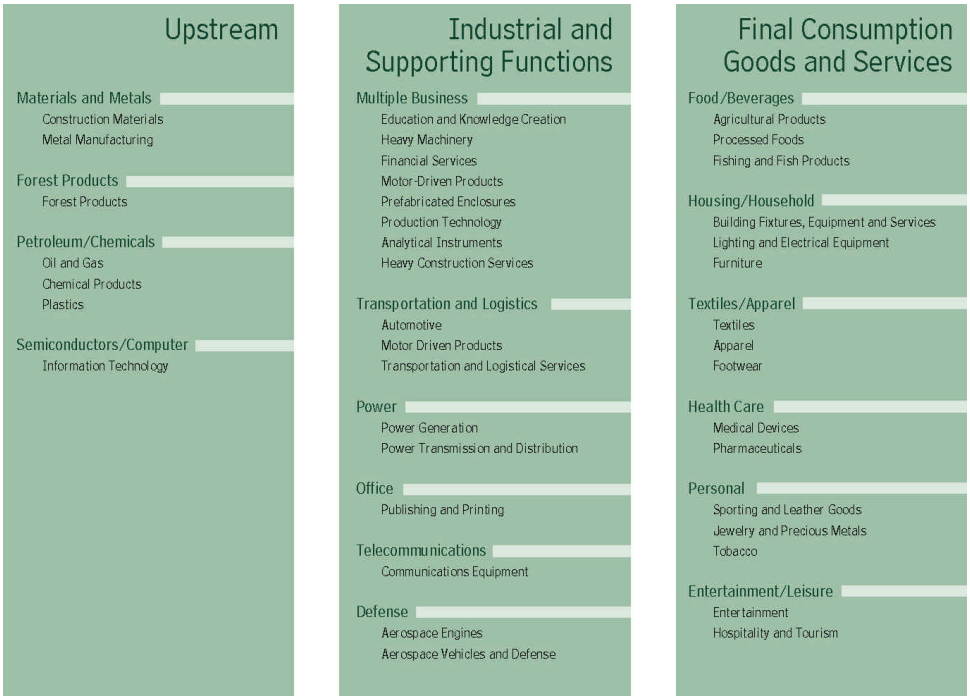
Especially in advanced nations such as the United States, regional economies are specialized, with each region strong in a different mix of industry clusters. Comparing regional economies has been difficult because clusters have not been systematically identified or mapped across all U.S. regions. To 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 Project provides an objective, quantitative way to profile regional economies, compare them over time, and measure the strength, evolution, and performance of the region's clusters. 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.

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 time 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 (excluding agriculture and government) on employment, establishments, and wages by four-digit Standard Industrial Classification (SIC) code by United States county. In addition, United States patent data by location of inventor are allocated to industries and clusters using a concordance of technology classifications with SIC codes.
  - 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 (EAs), 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 related industries that are normally located together are linked by external economies and constitute a cluster.
- Clusters are defined initially using state-level data (n = 50). The robustness of clusters is tested using Economic Areas as the geographical unit.
- 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 define the cluster.
- In both cases, industries with "spurious" correlations to the cluster or co-locations due to the presence of several strong clusters in the same geographical area are eliminated using Input-Output tables, industry definitions, and industry knowledge.[7]
- Note that a given industry can be part of more than one cluster. This may reflect overly broad industry definitions. However, it is also the case that there are multiple forms of externalities, and some industries are suppliers or customers of many others. Thus, overlapping clusters are expected and important economically.
- This process resulted in 41 traded clusters in the United States economy. These are shown in the figure below, grouped into broad categories.
- Cluster industries are separated into "narrow" and "broad." Narrow industries are the subset of the industries that are most correlated with a given cluster. Broad industries are those with statistically significant locational correlations that are with the cluster, but with stronger locational correlations with another cluster.

- Analysis using narrow industries eliminates cluster overlaps. An industry is a narrow industry for only *one* cluster. We refer to the narrow industries as the *narrow cluster definition.*
- Analysis using both narrow and broad industries includes the overlap among clusters. This overlap is important to understanding cluster competitiveness, but leads to double counting of employment, which leads to difficulties of interpretation for some analyses. We refer to clusters including both narrow and broad industries as the *broad cluster definition.*
- Subclusters, or subsets of cluster industries that are more strongly correlated with each other, are defined for each cluster. Subclusters are separately defined for narrow and broad industries. There are 244 subclusters of narrow industries and 245 subclusters of broad industries within the 41 traded clusters.
- We also group 241 local industries into clusters using industry knowledge. There are 16 local clusters ranging from local health services to local utilities to local retail clothing and accessories. We did not analyze local clusters extensively in this project, instead focusing on cross-regional competition. Doing so would be meaningful for examining the competition among counties within a metropolitan area.



ASSESSMENT OF THE 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 first examine overall competitiveness with special emphasis on the environment for innovation. Exhibit 18 on the following page illustrates some of the dimensions of the overall business environment analyzed in each region.

Exhibit 18: 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 for collaboration
Attitudes toward Value Creatiion	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. All clusters are important to the regional economy and are worth of study. However, 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. Exhibit 19 lists the clusters analyzed in each region.

Exhibit 19: Regions, Clusters, and Unique Data

San Diego	Wichita	Pittsburgh	Research Triangle	Atlanta	National Report
Pharmaceuticals / Biotechnology Communications Equipment	Plastics Aerospace Vehicles and Defense	Pharmaceuticals/ Biotechnology Information Technology Production Technology	Pharmaceuticals/ Biotechnology Communications Equipment Shorter Case Studies of Chemicals, Textiles and Plastics	Financial Services Information Technology Transportation and Logistics	Lessons from Cluster Mapping Project Lessons from Regional Analyses Lessons from Cluster Analyses
Interviews 49	Interviews 74	Interviews 51	Interviews 47	Interviews 43	Interviews 264
Surveys 232	Surveys 138	Surveys 202	Surveys 251	Surveys 202	Surveys 1025

Clusters were chosen for analysis 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 41 traded clusters in the United States economy were analyzed in at least one region. We also examined the same cluster (e.g., pharmaceutical / biotechnology in San Diego and the Research Triangle) in more than one region to investigate differences across regions in the economic and innovation performance of the cluster.

To assess the performance of a cluster, we compared a particular regional cluster (e.g., pharmaceutical / biotechnology in the Research Triangle) to the national cluster and to other benchmark regions (e.g., the pharmaceutical / biotechnology 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 about the region's competitive circumstances and important to understanding how the region might expand its economic base into new fields.

IMPLICATIONS FOR THE REGIONAL AGENDA

The study revealed many implications for local leaders at both the regional and cluster level. Implications cut across government and the private sector, and other institutions such as universities and trade groups. Some of the most important implications arose in the following areas:

- Reasons for the region's past successes;
- Areas of the business environment that need improvement;
- Issues and opportunities facing particular clusters; and
- Opportunities for regional growth that are not being pursued.

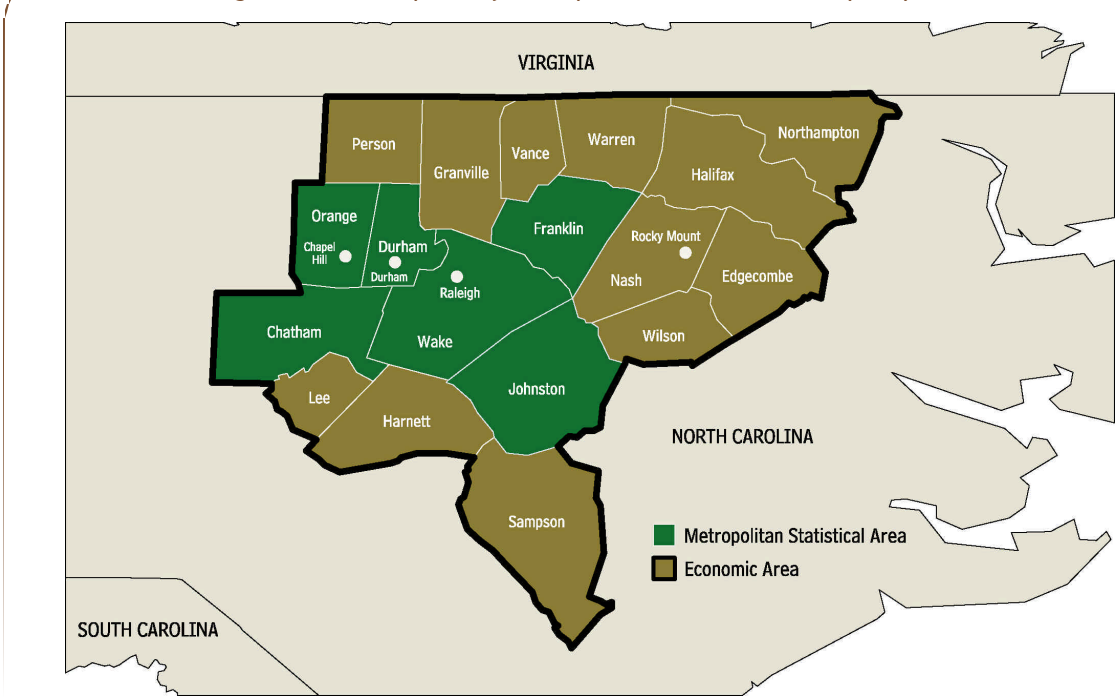
3 ASSESSMENT OF THE RESEARCH TRIANGLE REGIONAL ECONOMY

The current success of the Research Triangle economy, as with any economy, grows out of a decades long process. It began with investments in education and the development of a strong core of world-class research centers. These institutions, which over the years have enjoyed considerable federal and state funding, are the taproots of the region's economic growth. The Research Triangle 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 also been able to recruit well-known corporations to the region, mainly in the pharmaceutical / biotechnology and communications equipment industries. Today, the Research Triangle's economy is growing and contains a more diverse set of industries than was the case four decades ago when the economy was heavily dependent on agriculture and textiles.

For all its progress, however, and in part because of this progress, the Research Triangle faces significant challenges. The region is among the fastest growing metropolitan regions in the nation.[8] This fast growth has created significant infrastructure problems, especially in relation to over-clogged roads and traffic. Wages in the Research Triangle, even in advanced technology industries, are only slightly ahead of 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. More important, the region's economic development strategy has tended to focus on limited "high-tech" clusters while ignoring other equally relevant clusters in traditional industries. The region also suffers from a dispersed leadership among too many jurisdictions, which has led to weak cooperation among urban and rural geographic areas.

Our analysis focuses on the economy of six counties, Chatham, Durham, Franklin, Johnston, Orange, and Wake, which corresponds with the Raleigh-Durham-Chapel Hill Metropolitan Statistical Area (MSA), as defined by the United States Department of Commerce. In some cases we also study the Raleigh-Durham-Chapel Hill Economic Area (EA) which is defined as the MSA plus the following twelve counties: Edgecombe, Granville, Halifax, Harnett, Lee, Nash, Northampton, Person, Sampson, Vance, Warren, and Wilson (see Exhibit 20 on the following page).

Exhibit 20: Raleigh-Durham-Chapel Hill, Metropolitan Statistical Area (MSA) and Economic Area (EA)



Source: U.S. Census

We begin with a brief historical perspective, which is essential to understanding the Research Triangle'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 RESEARCH TRIANGLE REGIONAL ECONOMY

The history of the Research Triangle is inextricably tied to the land and those who helped develop it. From the 1600s through the 1800s, the Research Triangle's comparative advantage was mainly based on plentiful natural resources, fertile land, and a long growing season. As a result, agriculture prospered during this period and the region, with its connection to the rest of the state's rural-based economy, became an international leader in crops such as tobacco, and textiles.

These two industries, tobacco and textiles, provided the main source of business and wealth for the region during this time. More specifically, they also allowed several individuals to prosper not only locally, but also nationally and internationally as well. Due to their immense wealth and clear sense of community involvement, these individuals would provide the key to the region's economic development as it entered the 20th century.

Establishment of Entrepreneurs-Philanthropists. During the mid-to-late 1800s, the region's agriculture entrepreneurs not only became hugely successful, they also gave back to their communities. Among them are Dr. Bartlett Durham for whom the city of Durham is named and whose1849 land grant led to the region's major railroad station, and Erwin Mills, who established the Erwin Cotton Mills — the world's first mill to produce denim — in 1893.

The region's most successful mix of entrepreneur-philanthropist is best embodied, however, by Washington Duke and his son James B. Duke, both of who formed the American Tobacco Company in 1890. It was Duke's highly innovative and sophisticated marketing strategies that propelled American Tobacco into international prominence, and put the area on the world's economic map. It was also that family's philanthropy that created the underpinnings for some of the most lasting and important regional institutions. For example, in 1887 Trinity College moved from Randolph County to Durham through the generosity of Washington Duke and Julian Carr, who donated money and land to facilitate the move. Following a $40 million donation by Washington Duke's son, James Buchanan Duke, Trinity College was renamed Duke University in 1924.

This impressive philanthropic start laid the foundations for the region's gradual transition from agriculture to manufacturing to a knowledge-based economy. From the 1890s through the 1950s the region emerged as a leader in not only tobacco, but also textiles and apparel. Yet, as the region became more and more integrated into the global economy, it became increasingly clear to local leaders that these traditional industries were neither stable enough nor able to provide high wages in the long run. As the Research Triangle region entered the 1950s it did so in relatively poor condition, with little diversification away from its traditional industries, in an increasingly uncompetitive global position, and with half of its population as farmers. In 1951, 17 percent of North Carolina income came directly from agriculture. Only Arkansas and Mississippi had a heavier reliance on farming.[9]

The region's economy stagnated as farmers left their farms, as jobs in tobacco became more and more mechanized, and as the textile industry began to feel strong competition from Asia and other regions. Worse still was the fact that many of the region's graduates were leaving for lucrative jobs outside the state, creating a true "brain drain" on the region.[10]

Somehow, the region's leaders needed to bring in more research and educational wealth if the region was to prosper. The establishment of Duke University Medical School in 1930 and its modest growth in the 1950s was one of the region's first steps towards building a biomedical educational powerhouse. More momentum was needed if the region was going to transition to a truly knowledge-based economy. Part of the solution lay in not only increasing research in the region's private and state universities, but in attracting companies that conducted a disproportionate share of research and development as part of their business.

Selling companies on the idea of relocating their research facilities to North Carolina was not a simple task. Most companies built their research facilities close to their manufacturing facilities. If they were not planning on moving their entire company to North Carolina, there was little chance they would only set up a research facility here.

It was in 1958, with the economy of North Carolina still dependent on maturing industries such as tobacco and textiles, that the state's government and business leaders, including North Carolina Governor Luther Hodges, set out to foster economic development through far-sighted investments in universities, research centers, and infrastructure. Governor Hodges, who earned a reputation as the "businessman's

governor," led education reform, devoted significant resources to post-secondary education, built vocational schools, and embarked on an persuasive industrial recruitment and incentive program.

Challenged by discontinuities, cluster-generating companies and crusading individuals (e.g., former Governors since Hodges) forged inter-relationships, promoted the development of supportive institutions (e.g. the Research Triangle Foundation), and pioneered the growth of the present clusters. As mentioned by a prominent economic development official in one of the cluster interviews, "The shift from an agricultural focus took real leadership. As a result, the aspirations and expectations of the citizenry have changed a lot over the last 20-30 years."[11]

Establishment of Research Triangle Park. Against this background, the idea for the "Research Triangle" emerged. Leaders from universities, business, and government cooperated to create what has become one of the most successful planned science parks in the world, the Research Triangle Park. The 7,000-acre "Triangle" is defined by three universities located less than 30 miles apart: North Carolina State University in Raleigh, the University of North Carolina-Chapel Hill, and Duke University in Durham.

These three educational institutions formed the pillars of the region's knowledge-based economy by providing world-class research facilities as well as a critical mass of scientists, researchers, and technicians. Their research capabilities complement other research institutions located in the Park, including the North Carolina Biotechnology Center, a state-supported initiative established in 1981 that provides grants and creative services to support biotechnology companies, and, the partially state-funded Microelectronics Center of North Carolina — founded in 1980 — which offers advanced Campus at North Carolina State University's, a 1,334-acre research park adjacent to North Carolina State University's main campus that is being developed as a "technopolis" of corporate, government, and academic R&D facilities and business incubators, with an town center, executive conference facilities, a hotel, upscale housing, and recreational amenities.

All these institutions forged powerful informal groups, 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 support the University of North Carolina-Chapel Hill, Duke University, and North Carolina State University campuses and other institutions to identify and promote extensions to them. Over time the research institutions went beyond the development of the pharmaceutical / biotechnology cluster and began to interrelate with other local clusters (e.g., communications equipment and information technology). For example, in 1965 the Triangle Universities Computation Center was formed to operate a mainframe computer that none of the three schools could have afforded separately. The computing power afforded by such a joint effort bridged the research gap for 25 years until smaller, more powerful computers were ushered in during the latter part of the century.

Today, the three major universities in the region still cooperate on such issues as sharing a nuclear laboratory at Duke University, a research luxury that no school could justify on its own. Uncharacteristically close cooperation between the three institutions helps the region win more federal research dollars than would otherwise be the case. But the "if we build it, they will come" story is only half of the reason for the Research Triangle Park's success. There is an equally important private-sector presence that helps explain the region's ability to compete. The growing presence of research-oriented companies has promoted, often consciously and deliberately, the development of needed supporting institutions for collaboration. As one interviewee put it, "There is a strong 'helping' culture in the region because when it first started trying to

develop, there was not very much to fight over. As a result, people developed a collaborative approach to solving problems, an approach that became ingrained in the way they did things."[12]

The Clusters of Today. The Research Triangle's contemporary economy is largely the product of its beginnings as an entrepreneurial, philanthropic, research and development hub (see Exhibit 21 below). Almost every one of the Research Triangle's large and growing clusters grew due to the presence of the communications equipment or bio-science research, research made possible by a successful and engaged private and public leadership. As told by an interviewee, "The universities, especially North Carolina State University, have a long history of working closely with business due to their roots in the old land-grant system. This is very clearly reflected in the innovative approach used to build the Centennial Campus where businesses were invited into campus to help build the buildings."[13] Had past leaders failed to foster these two sets of economic assets, it is difficult to imagine the Research Triangle partaking so fully in the rapid growth experienced by the United States in the 1990s.

Exhibit 21: Regional Economic Development Timeline, Research Triangle

Nevertheless, challenges do remain for the region as it goes beyond the original plan for the Research Triangle Park, as its clusters grow to national prominence, and as the region grows in population. One thorny issue sure to come up again is the difficulties associated with divergent points of view and multiple jurisdictions, something that perhaps is not as palpable in other successful regions in the state. As mentioned by a prominent educational leader in the community, "The Research Triangle is comprised by three main regions with three different cultures, and three different styles of government, whereas Charlotte is hierarchical, with a single corporate culture where a few individuals can make things happen."[14] Additional challenges include infrastructure problems, an economic development strategy focused on limited "high-tech" clusters, and a myopic view of the region as to exclude the economic area as relevant to the region's continued success.

REGIONAL ECONOMIC PERFORMANCE

The Research Triangle economy does well in most measures of performance. The recession of the early 1990s was less severe in the Research Triangle than in other parts of the country, with the subsequent employment growth having been greater. It exhibits low unemployment rates, superb R&D funding, and average wages that are at or slightly above the national averages. Yet the cost of living is higher than the national average, and interviewees frequently expressed concern about the rising cost of living. Exports are 10% lower than the national average and not growing as fast.

The region's innovation output has also been strong over the past decade. Establishment formation has been growing at twice the national rate; the region enjoys excellent venture capital (VC) funding per worker and strong patent registration. Initial Public Offerings (IPOs), however, have been lagging the national average.

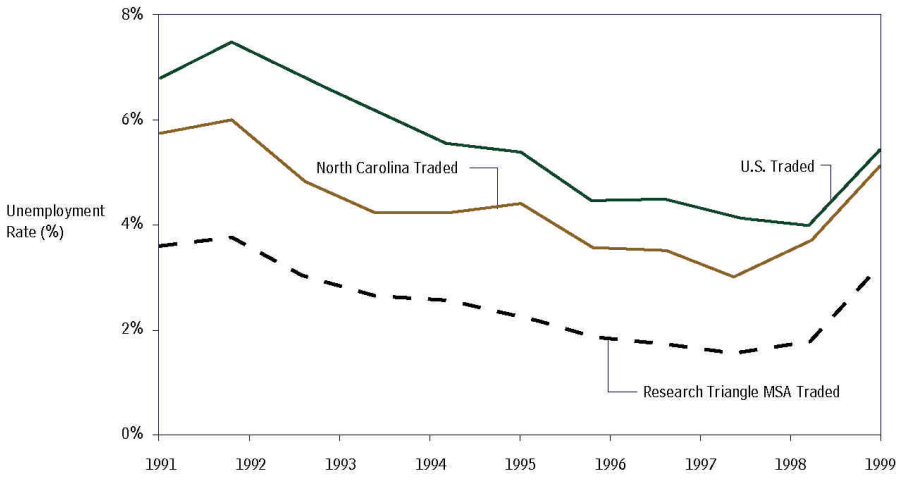
Indicators of Overall Economic Performance

To assess the overall economic performance of the Research Triangle's regional economy, we compare it to the nation and several benchmark regions on the following metrics: population growth, employment, unemployment, average wages, cost of living, and exports.

Employment. The Research Triangle economy has performed well in terms of employment growth over the last decade. The number of civilian employees in 2000 was 648,981, up from 504,790 in 1991.[15] From 1991-2000, the compound annual rate of growth of employment in the Research Triangle was 2.6%, well above the national rate of 1.7%.

Unemployment. The unemployment rate in the Research Triangle has been consistently lower than the North Carolina and national averages, reaching a modest high of 3.8% in 1992, and a spectacular low of 1.6% in 1999. (See Exhibit 22 below). The unemployment rate for 2000 was 1.7%, but has risen steadily since then to 3.3% in September 2001. A similar rise in unemployment rates occurred in North Carolina (5.2%) and the nation (5.4%) in September 2001.

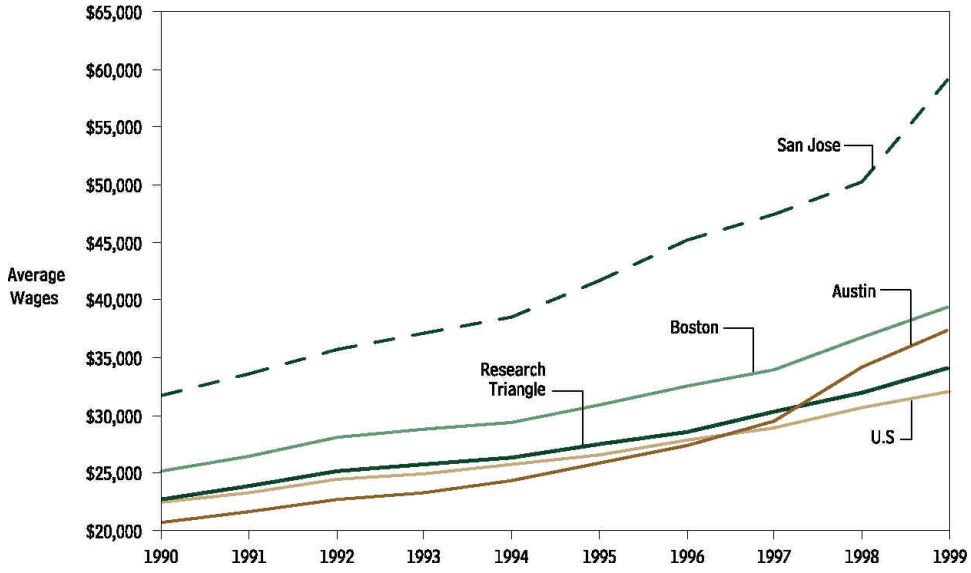
Exhibit 22: Unemployment by Region, 1991 to 2001 (September)



Note: 2001 numbers are for September, 2001
Source: U.S. Bureau of Labor Statistics

Average Wages. The average wages in the Research Triangle MSA in 1999 were $34,113, above the national average of $32,711, or approximately 4.3% above the national average. Wage growth from 1990 to 1999 was 4.3%, slightly faster than the national growth rate of 4.0%. Growth in average wages has been slightly slower than other benchmark regions. (See Exhibit 23).

Exhibit 23: Average Wages, Select Geographic Regions, 1990-1999



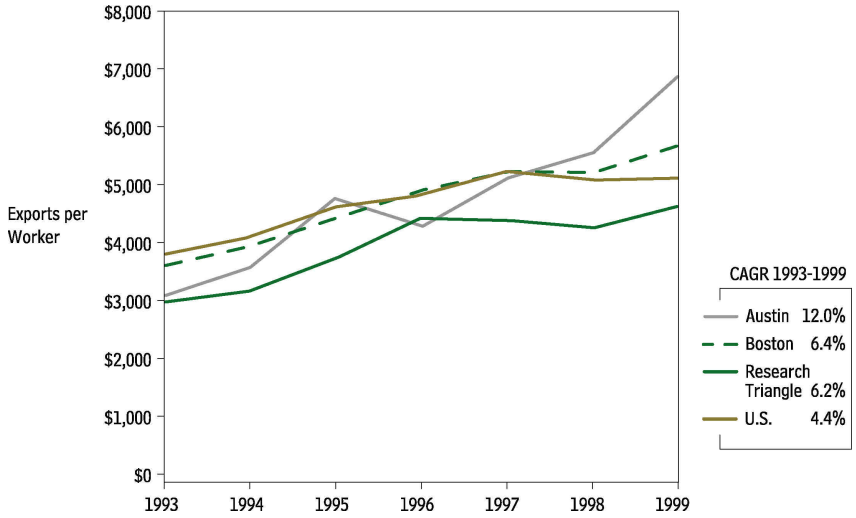
Note: Average wages are nomimal
Source: BEA

Cost of Living. According to the American Chamber of Commerce Research Association (ACCRA) estimates, the cost of living in the Research Triangle MSA was approximately 2.6% higher than the average US metro area.[16] In 2000, housing costs were an estimated 4.7% higher than the national average. The problems brought about by this slightly higher cost of living are compounded by the fact that wages are only 4.3% higher than the national average, producing a 2.1% gap.

The median price for a two-bedroom home in the Research Triangle in 2000 was estimated to be $185,600 (an 8.4% increase from 1999 prices), compared to $140,900 (a 3.8% increase from 1999) for Charlotte/Gastonia/Rock Hill, North Carolina/South Carolina, and $125,000 (a –0.6% decrease) for Greensboro/Winston-Salem/High Point. The Research Triangle region was also higher than other benchmark regions, including Austin, Texas ($153,200 in 2000 and growing at 14.6%), but lower than Boston, Massachusetts ($329,500 in 2000 and growing at 13.2%).

Exports. The Research Triangle per worker exports are $4,710 versus $5,212 for the United States, $6,969 for Austin, and $5,734 for Boston. Total export growth has been healthy when compared to the nation, but less impressive when compared to benchmark regions; from 1993 to 1999, the Research Triangle has an export CAGR of 6.2%, versus 4.4% for the United States, 12.0% for Austin, and 6.4% for Boston. (See Exhibit 24 on the following page).

Exhibit 24: Exports per Worker by Region, 1993 to 1999



Note: Data are for manufactured and commodity exports only; regions are by MSA`
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 the Research Triangle to the nation and benchmark regions in the following metrics: patents, venture capital investments, the prevalence of fast growing companies, initial public offerings, and establishment growth. Patents measure early stage innovation, whereas venture funding, fast growth firms, and IPOs measure innovation at successive stages. The Research Triangle 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 is available, inventors in the Research Triangle MSA registered 939 patents, ranking the region 27th among U.S. metro areas. The Research Triangle MSA produced 14.5 patents per 10,000 workers, more than twice the national average of 6.3 and on par with benchmark regions like Boston (14.6), but well behind San Jose (58.8) and Austin (22.2). The Research Triangle's annual patent growth rate of 10.9% between 1991 to 1999 was faster than the national rate of 4.2%, Boston's rate of 6.5%, and only slightly behind San Jose's 14.2% and Austin's 11.7%.

An analysis of patents per organization in the Research Triangle MSA between 1995 to 1999 shows that the region has a handful of organizations, both private and public, that exhibit relatively high patent rates. Among firms, IBM, Ericsson, and Becton Dickison and Company led in number of registered patents during this period, while the three main universities in the region, North Carolina State University, University of North Carolina-Chapel Hill, and Duke University lagged benchmark educational institutions (see Exhibit 25 on the following page). Nevertheless, North Carolina State University currently gets good marks in technology transfer surveys—the Association of University Technology Managers recently ranked it 17th among 132 universities surveyed in such technology transfer metrics as amount of license income ($7,761,000), amount of research expenditures ($413,369,000), license income as a percentage of research expenditures (1.9%), and number of licenses and options yielding income (60).[17]

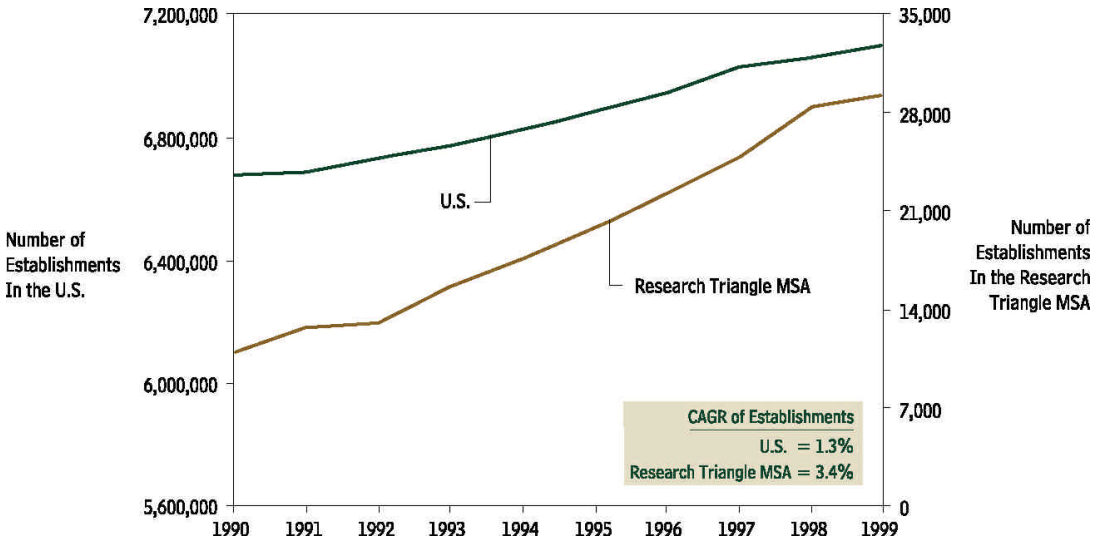
Exhibit 25: Patents by Organization, Research Triangle MSA, 1995 to 1999

	Organization	Patents Issued from 1995 to 1999
1	International Business Machines Corporation	495
2	Ericsson, Inc.	325
3	Becton, Dickinson and Company	128
4	North Carolina State University	128
5	Duke University	127
6	University of North Carolina — Chapel Hill	124
7	Square D Company	48
8	Novartis	46
9	ABB Power T&D Company, Inc.	44
10	Alcatel Network Systems, Inc.	43
11	Mitsubishi Semiconductor America, Inc.	41
12	Lord Corporation	36
13	Kennametal, Inc.	29
14	Rhone-Poulenc, Inc.	29
15	Telefonaktiebolaget LM Ericsson	28
16	Caterpillar, Inc.	26
17	Cree Research, Inc.	26
18	E.I. DuPont De Nemours and Company	26
19	MCNC	25
20	Raychem Corporation	24
21	Reichhold Chemicals, Inc.	24
22	American Sterilizer Company	21
23	Siemens Energey and Automation, Inc.	21
24	Northern Telecom Limited	20
25	Research Triangle Institute	20
	Benchmarks	**Patents Issued from 1995 to 1999**
	Massachusetts Institute of Technology	509
	John Hopkins University	233
	Stanford University	204

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

Later Stage Innovation: Establishments Formation. Research Triangle MSA's establishments for all industries grew from 23,484 in 1990 to 32,767 in 1999, which produced an annual growth rate between 1990 and 1999 of 3.4%, compared to 1.3% for the nation and 2.0% for North Carolina. The Research Triangle's strong establishment growth is mainly concentrated in a handful of industries, including information retrieval services (39.5%), computer facilities management (35.1%), biological products, except diagnostic (32.3%), and computer related services, n.e.c., (24.5%). (See Exhibit 26).

Exhibit 26: Establishments Formation by Region, 1990 to 1999

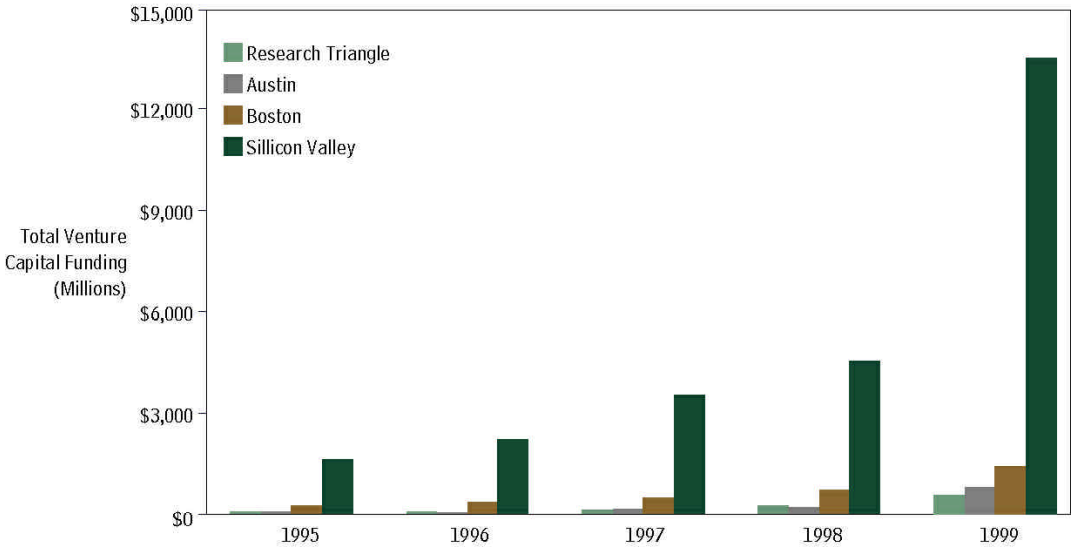


Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

Venture Capital Investments. From 1995 to 1999 Research Triangle MSA firms received $1.08 billion in venture capital. At roughly $905 per civilian worker in 1999, this amount is more than three times the national average of $266 per worker. However, the Research Triangle MSA lags benchmark regions such as Austin ($1,975 per worker). The Research Triangle MSA's compound annual growth of 55.7% of venture capital investments over this period is above the national average of 41.8% and Boston's rate of 50.5%, but well below Austin's rate of 64.2%. (See Exhibit 27 on the following page).

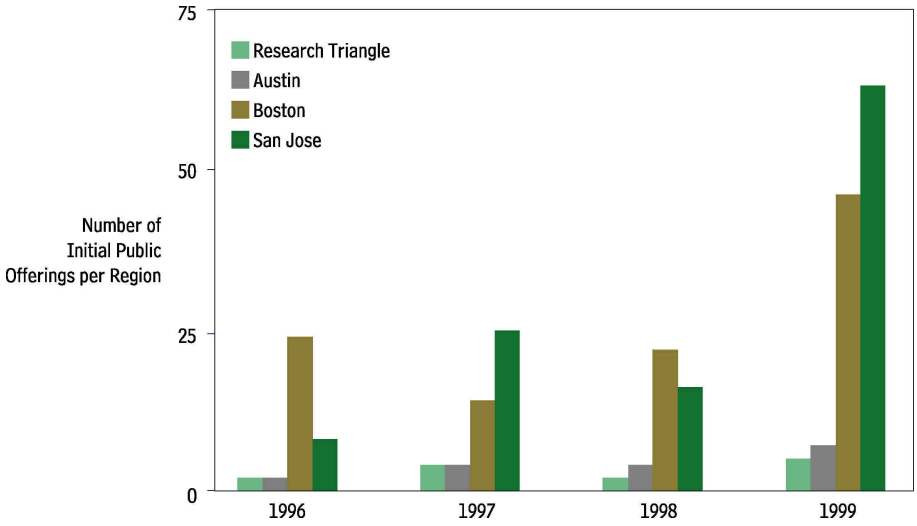
Initial Public Offerings (IPOs). The Research Triangle MSA had 13 companies that went public from 1996 to 1999, more than Austin, but well behind Boston—which had 106 IPOs—and San Jose—which had 112 (see Exhibit 28 on the following page). The Research Triangle MSA's growth rate in IPOs during that time was 25.7%, more than the national mean (21.8%) and Boston (17.7%), but less than Austin (36.8%) and San Jose (67.5%).

Exhibit 27: Venture Capital Funding by Region, 1995 to 1999



Source: PwC MoneyTree Database

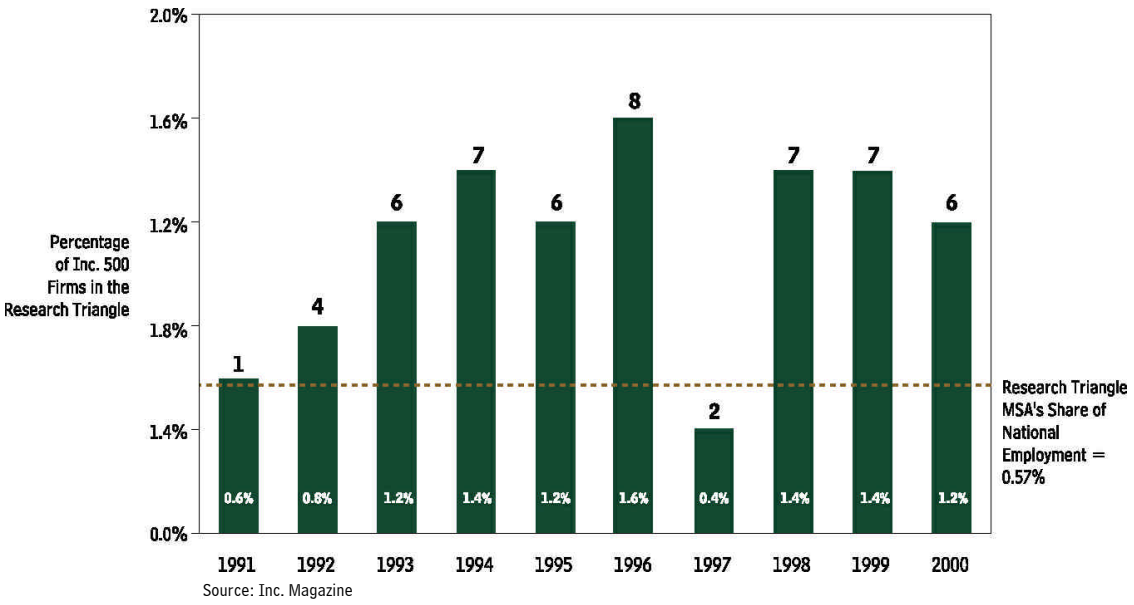
Exhibit 28: Initial Public Offerings by Region, 1996 to 1999



Source: Hoover's IPO Central

Fast Growth Firms. The Research Triangle MSA has a number of rapidly growing firms. Exhibit 29 shows the percentage of Inc. 500 companies in the Research Triangle on the vertical axis (exact number at top of bar). In the worst year out of the last ten, the Research Triangle had 0.4% of the Inc. 500 companies, slightly less than its share of national employment. The Research Triangle's growth rate of Inc. 500 companies from 1991 to 2000 was 7.2%; above North Carolina's rate of 4.1%, California's rate of 1.8%, and Massachusetts' rate of 1.2%.

Exhibit 29: Share and Number of Inc. 500 Firms, Research Triangle MSA, 1991 to 2000



Source: Inc. Magazine

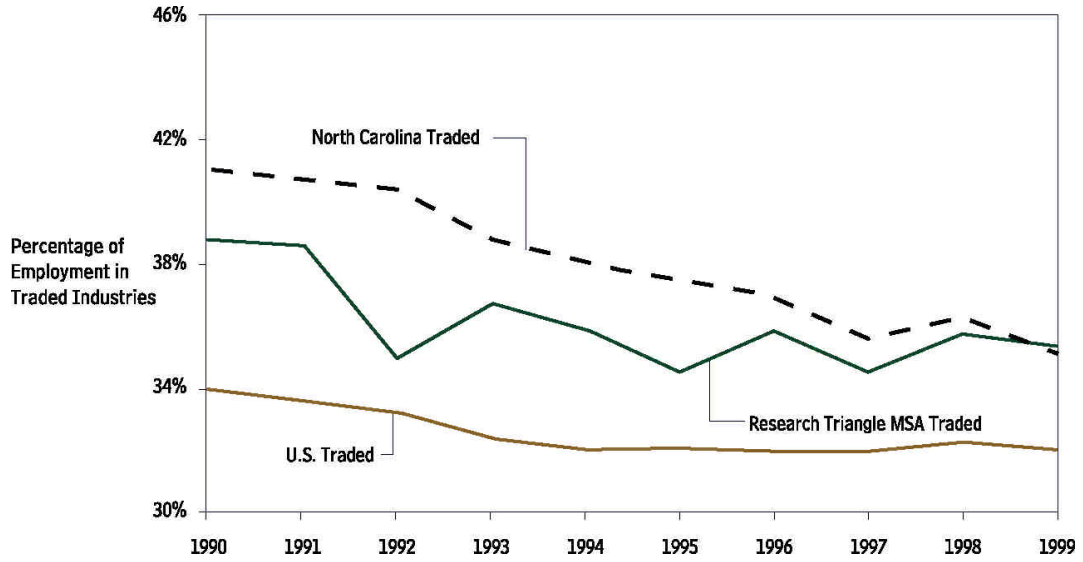
Evolution and Composition of the Regional Economy

The Research Triangle has a relatively small share of its employment in traded industries, although it does have a relatively large number of strong and growing clusters. Over time, former agriculture and textile workers are finding work in other clusters and the Research Triangle 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 Research Triangle MSA economy, accounting for 32.8% of the region's total employment in 2000.[18] Government is the second largest sector, employing 18.5% of the Research Triangle MSA's workers. Retail trade is also a large sector at 16.4% of the Research Triangle MSA employment in 2000. Manufacturing is the next largest at 12.7% of total employment in 2000. Farm employment is relatively small at 0.7% of the Research Triangle MSA's employment in 2000. The presence of the state government in Raleigh and the state universities in Chapel Hill and Raleigh help the region weather recessions to some degree, while the low numbers of workers in manufacturing might help explain the relative weak export performance numbers.

Employment in higher paying traded industries is decreasing in the Research Triangle MSA, as indicated in Exhibit 30.[19] The Research Triangle MSA lost more employment in traded industries in the early 1990s, than either the U.S. or North Carolina. However, in 1993, 1996, and then again in 1998, the rate of growth of jobs in traded industries in the Research Triangle MSA was faster than in non-traded industries. In 1999 the Research Triangle MSA had 35.4% of its total employment in traded clusters, while the EA had 36.4% of its total employment in traded clusters.

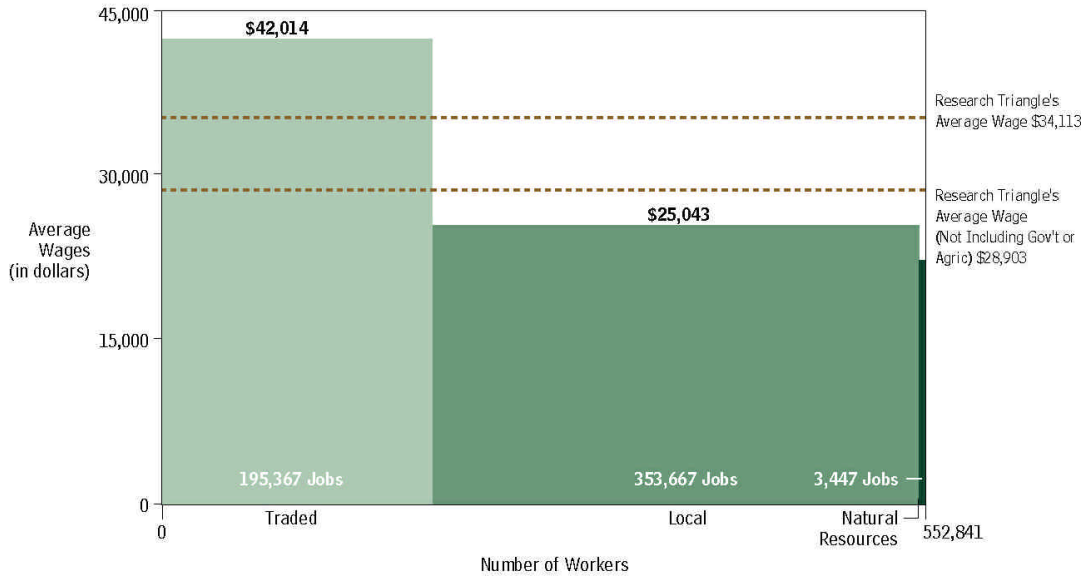
Exhibit 30: Traded vs. Non-Traded Employment by Region, 1990 to 1999



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

The composition of average wages in the Research Triangle MSA also varies by traded, local, or natural resource-based jobs. Exhibit 31 below shows the average wages for 1999, with traded jobs achieving relatively higher average wages than local jobs or natural resource jobs. Nevertheless, the majority of jobs in the Research Triangle MSA continue to be in the local economy.

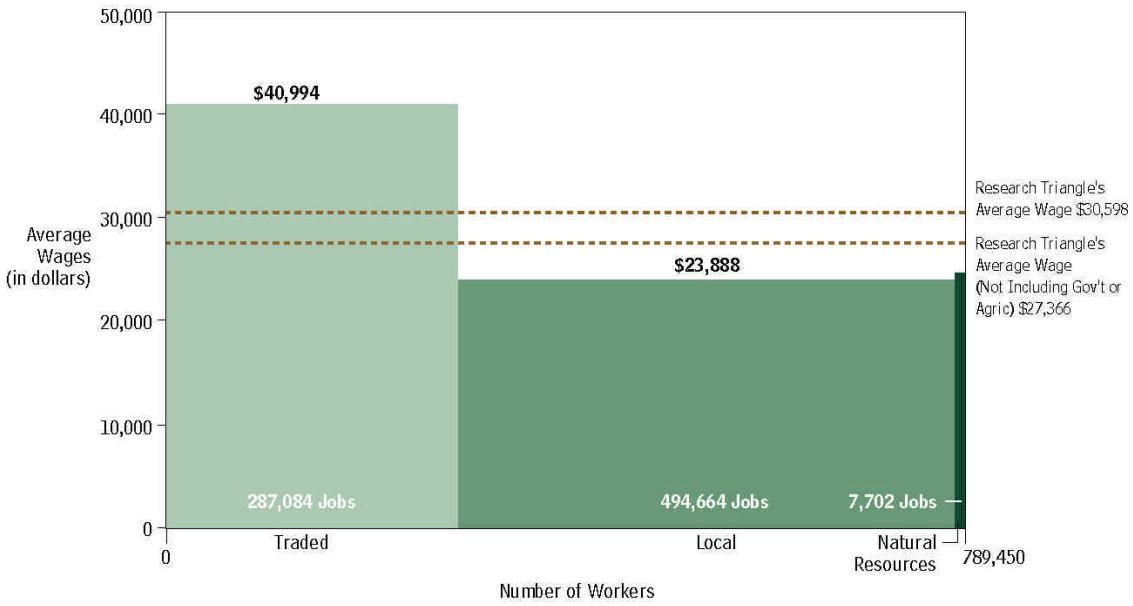
Exhibit 31: Composition of Average Wages, Research Triangle MSA, 1999



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

The composition of average wages in the Research Triangle EA also varies by traded, local or natural resource-based jobs. Exhibit 32 below shows the average wages for 1999, with traded jobs again achieving much higher average wages than local jobs or natural resource jobs, but somewhat lower than the MSA numbers. Natural Resources jobs also appear to constitute a higher percentage of the total economy. Nevertheless, the majority of jobs in the Research Triangle EA continue to be in the local economy.

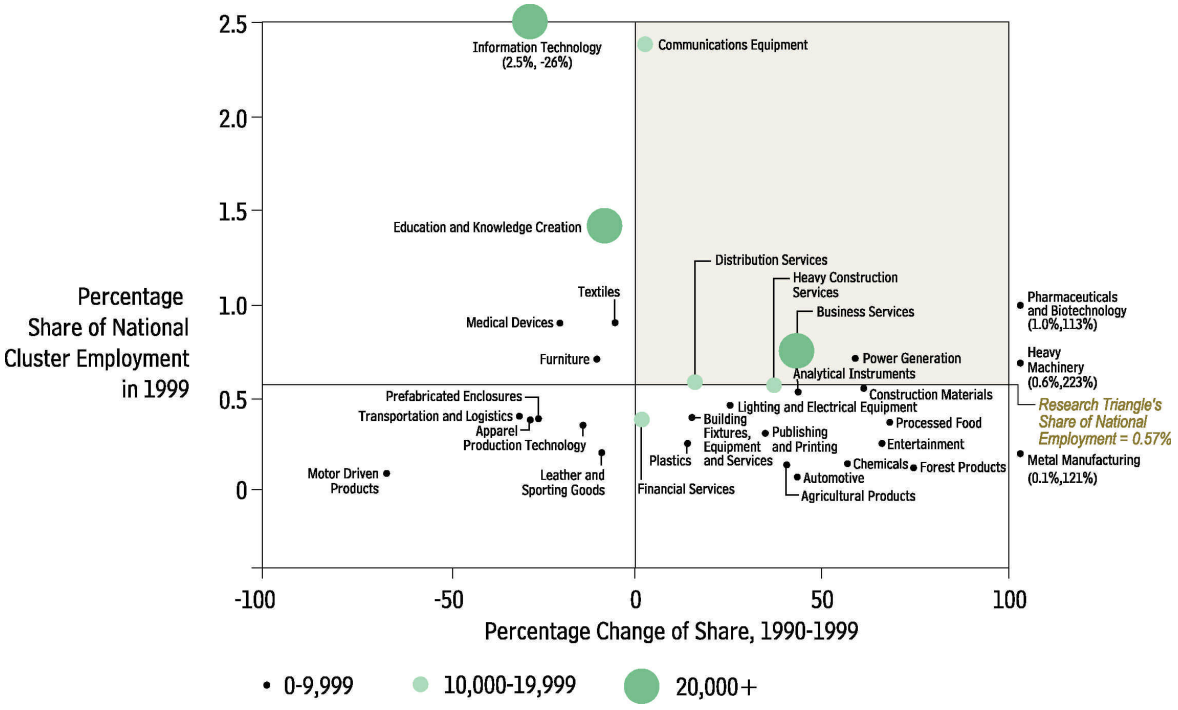
Exhibit 32: Composition of Average Wages, Research Triangle EA, 1999



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

Clusters. Exhibit 33 on the following page shows the Research Triangle MSA's employment share and growth in the 41 traded clusters in the United States economy (narrow cluster definition). The Research Triangle MSA has 0.57% of total national employment; i.e., the point at which the horizontal axis crosses the vertical axis. Clusters above the horizontal axis are relatively concentrated in the Research Triangle MSA, and clusters to the right of the vertical axis have grown from 1990 to 1999. The upper right quadrant represents clusters that have a relatively higher share of national employment and are growing in share of national employment. In the Research Triangle MSA, 34% of traded industry employment is in the upper right quadrant. With six clusters in this upper right-hand quadrant, the Research Triangle MSA's economy is relatively undiversified. If information technology and education and knowledge creation are added (two clusters which would be included if 1988 to 2000 numbers were compared), then the upper right quadrant would represent 61% of traded industry employment.

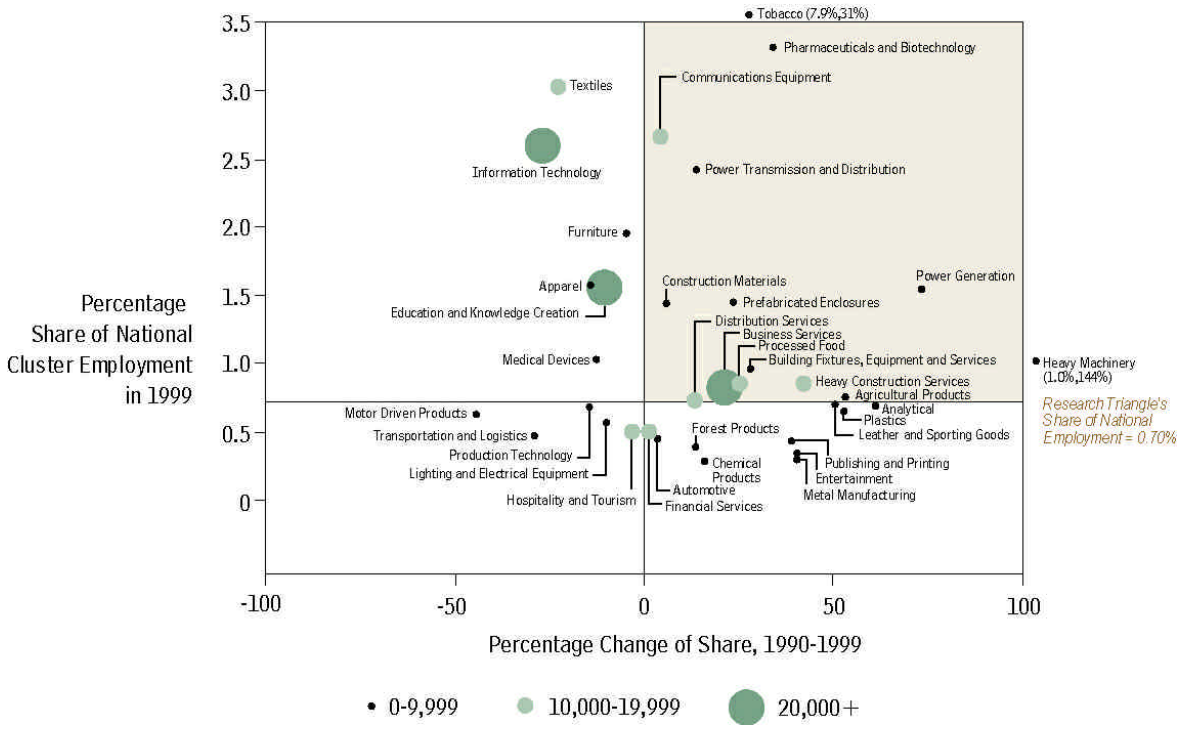
Exhibit 33: Specialization of the Economy, Research Triangle MSA, Narrow Cluster Definition



Note: (y-axis, x-axis)
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

Exhibit 34, on the next page, shows the Research Triangle EA's employment share and growth in the 41 traded clusters in the United States economy (narrow cluster definition). The Research Triangle EA has 0.70% of total national employment; i.e., the point at which the horizontal axis crosses the vertical axis. Clusters above the horizontal axis are relatively concentrated in the Research Triangle, and clusters to the right of the vertical axis have grown from 1990 to 1999. The upper right quadrant represents clusters that have a relatively higher share of national employment and are growing in share of national employment. In the Research Triangle EA, 43% of traded industry employment is in the upper right quadrant. The presence of 14 clusters in the upper right quadrant in the Research Triangle (versus six in the MSA) indicates that the economy is more diversified if a larger geographical footprint is analyzed.

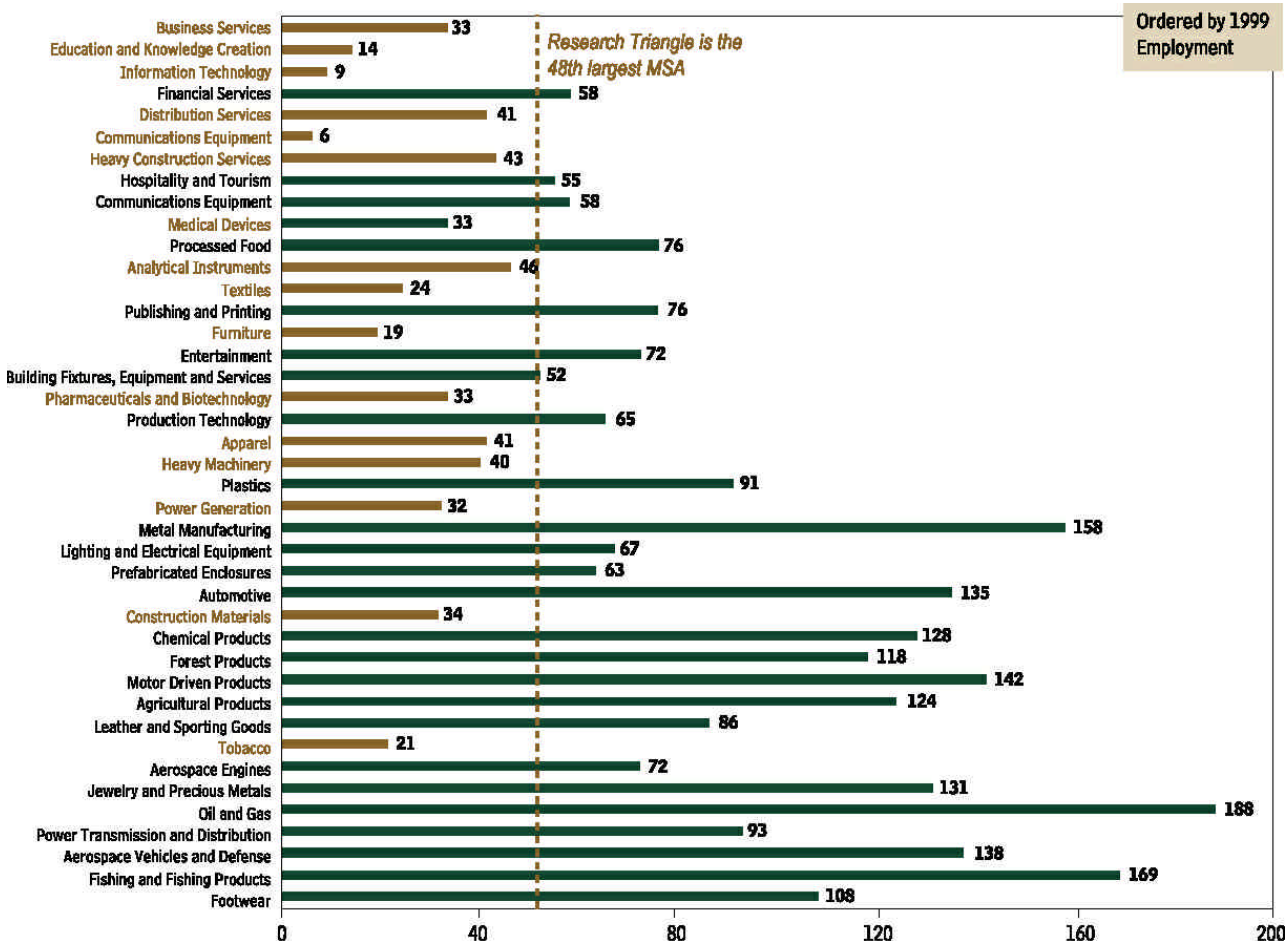
Exhibit 34: Specialization of the Research Triangle EA Economy, Narrow Cluster Definition



Note: (y-axis, x-axis)
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

Exhibit 35 shows the national ranking in terms of percentage share of national employment for each of the Research Triangle MSA's clusters (narrow cluster definition). In 2000, the Research Triangle was the 48th largest MSA and ranked 48th or higher in 16 out of 41 clusters in terms of share of national employment. Especially high-ranking clusters are communications equipment (sixth), information technology (ninth), education and knowledge creation (14th), and furniture (19th).

Exhibit 35: Cluster Rank by Share of National Employment, Research Triangle MSA, Narrow Cluster Definition, 1999



Note: Region is ranked among the 318 other Metropolitan areas

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

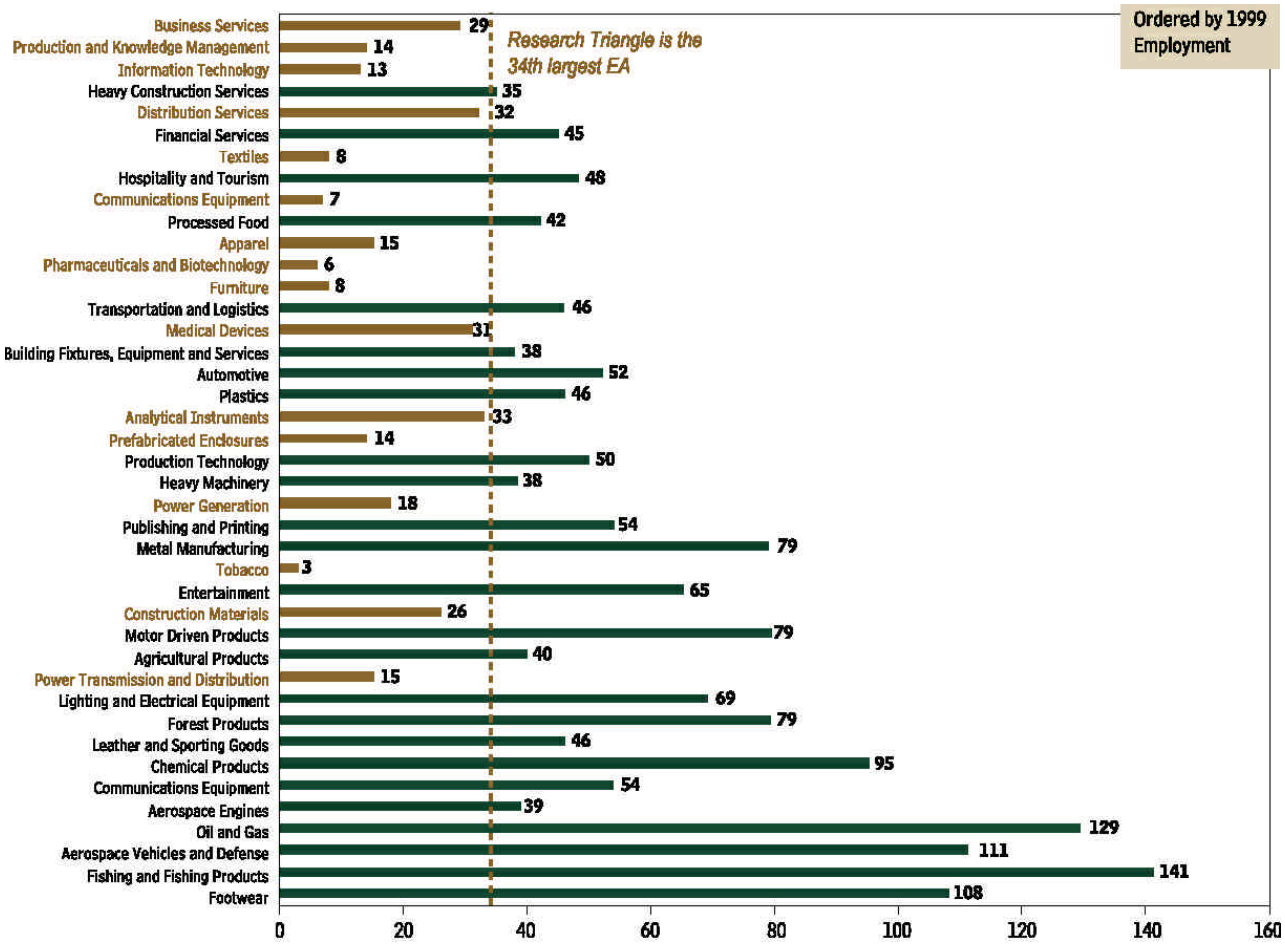
The fact that 16 clusters out of 41 clusters rank high in percentage of national employment points to a potential problem for the region: the Research Triangle MSA is not big enough to provide the necessary critical mass to justify being the headquarters of Fortune 500 companies. In fact, the only Fortune 500 company based in the Research Triangle area is Progress Energy (number 459). All other North Carolina firms on the Fortune 500 list are based in either Charlotte (with six companies on the list), Winston-Salem (with three companies), or Greensboro/Wilkesboro (with one each). In addition, out of North Carolina's top twenty largest private sector employers, only two companies have operations in the Research Triangle (IBM and Nortel, number four and number twenty respectively).[20]

With the exception of Progress Energy, Quintiles and SAS Institute, no Research Triangle-area company is big enough to be considered a major corporation, a disquieting statistic. Many professional services firms do not have a large presence in the Research Triangle because the region does not have that many large corporations based there. As one interviewee indicated, "A partner in our firm thought the region was promising and established an office in the Research Triangle in the early 1980s. He left by the late 1980s and things drifted because there weren't enough Fortune 1000 companies in the region to make it work."[21]

This not only has repercussions for ancillary services, it also has the potential to stymie leadership efforts of the caliber that made the region what it is today. As another executive adds, "People are concerned that the newcomers to the region will not share the same sense of responsibility nor provide the kind of local leadership that they should, particularly when many of the new businesses are headquartered elsewhere and so lack the same motivation for getting involved in the region."[22]

If an EA footprint is analyzed, however, the region has a stronger case for recruiting Fortune 500 headquarters to the region. Exhibit 36 below shows the national ranking in terms of percentage share of national employment of each of the Research Triangle EA's clusters (narrow cluster definition). In 2000, the Research Triangle was the 34th largest EA, and it ranked 34th or higher in 16 out of 40 clusters in terms of share of national employment. While this is the same number of clusters as were found in the MSA, the EA's 16 clusters generally rank higher than those in the MSA. Especially high-ranking clusters are tobacco (third), pharmaceutical and biotechnology (sixth), communications equipment (seventh), textiles (eight), and furniture (eighth), all of which are among the top ten in the nation.

Exhibit 36: Cluster Rank by Share of National Employment, Research Triangle EA, Narrow Cluster Definition, 1999



Note: Region is ranked among the 172 other Economic Areas
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

Research Triangle Park. The origin of the phrase "Research Triangle" is often attributed to Romeo Guest, the owner of a Greensboro-based construction company who noticed on a map of the area that the University of North Carolina-Chapel Hill, Duke University, and North Carolina State University in Raleigh formed a triangle. As a student at the Massachusetts Institute of Technology (MIT), Guest became aware of an area along Charles River Road called "Research Row" that was devoted to research projects. Knowing that research there was being done in cooperation with MIT, Guest envisioned the same kind of cooperation between Duke University, the University of North Carolina-Chapel Hill, and North Carolina State University.

It was then, during 1954 and 1955, that Guest, Robert Hanes, president of Winston-Salem based Wachovia Bank & Trust Company, and Governor Hodges met to discuss the state's need for more diversified industrial growth. In April 1955, Hodges, who was a successful Marshall Field executive making the transition to elected official, formed the Research Triangle Development Council (later incorporated as the Research Triangle Foundation) and asked Hanes to serve as its chairman. With a staff in place, the committee could now concentrate on raising money and purchasing the land that would be needed for a research park.

Guest then enlisted the help of one local real estate agent and, with Hanes, began looking for land and investors. Guest arranged a meeting between Governor Hodges and Karl Robbins, a wealthy New York industrialist and philanthropist who at one time had owned a textile mill in the vicinity of Pinehurst, North Carolina. Robbins eventually agreed to invest $1 million — $750,000 for land and $250,000 for water lines — and parcels of land were quietly bought, with the area being renamed the Evergreen Farm Company (later changed to the Pinelands Company). But Robbins did not want to fund the entire project, so Pinelands offered 500 shares of preferred stock and 500 shares of common stock at $100 per share.

Archie Davis succeeded Hanes as president of Wachovia, which was, at the time, the largest bank in North Carolina. When it was decided that one person should be in charge of raising voluntary contributions in the Pinelands Co., Hanes recommended Davis. Believing in the "generosity of spirit" of his fellow North Carolinians, Davis began his fund raising efforts in his hometown of Winston-Salem where businesses had already pledged more than $450,000. Both Davis and Hanes were well known throughout the state so it was easy for them to find investors from as far away as Asheville, although their affiliation with Wachovia made Winston-Salem their prime target. Plus, it was generally understood that a research center of this magnitude — no matter where it was located — would benefit all parts of the state.[23]

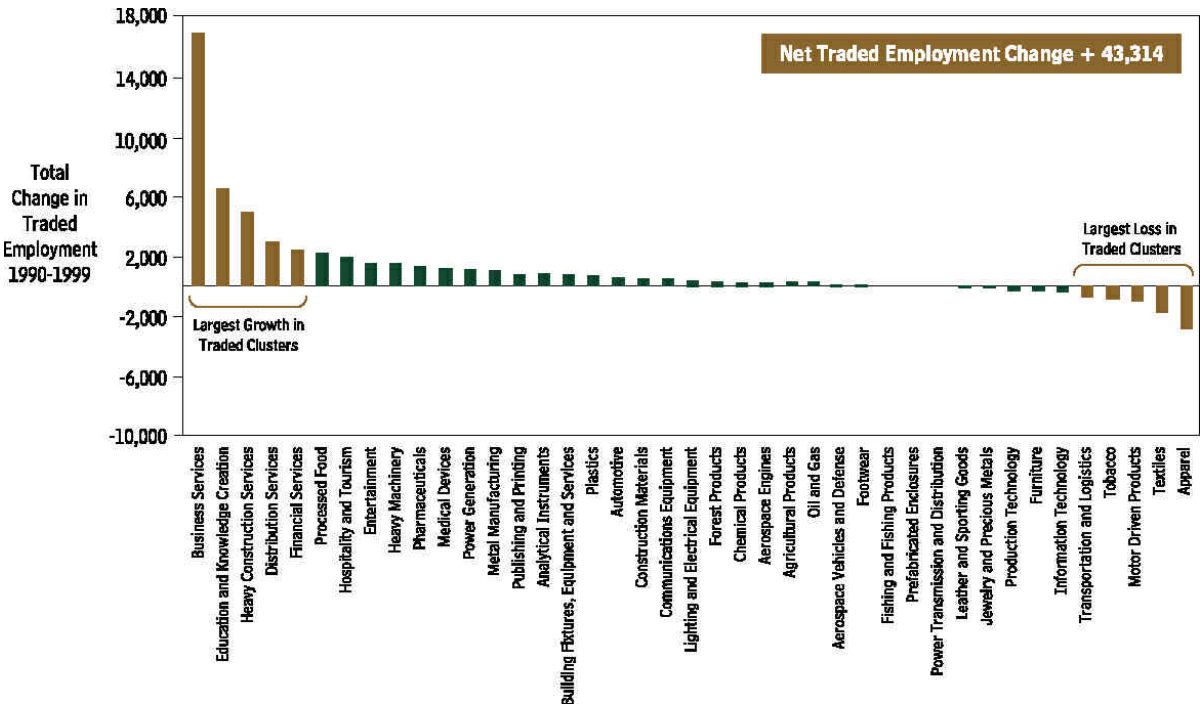
Both the Park, which was developed by Research Triangle Foundation, and its centerpiece, the Research Triangle Institute, thus came into formal existence at the end of 1958. The cities of Raleigh and Durham seized the opportunity by carving out from Durham pinelands a special Durham County tax district exclusively for research. Major textile companies such as Beaunit and Hercules and diversified chemical firms such as Chemstrand built R&D facilities in the Research Triangle Park's "first wave." The American Association of Textile Chemists and Colorists, which established its headquarters in the Park in 1964, is the surviving representative of the chemical-textile mix. The first federal facility, the United States Department of Agriculture Forestry Sciences Laboratory, also established itself in the Research Triangle Park at the time.[24]

The year 1965 is generally acknowledged to be the year when the Research Triangle Park turned the corner toward inevitable success. In back-to-back milestones, IBM and the United States Environmental

Protection Agency moved into the Research Triangle. Now, the Research Triangle Park is encompassed on three sides by the city of Durham with a portion in Wake County near Cary. Since then, the Park has grown to include more than 150 industrial and governmental installations employing more than 45,000 people and is considered by many to be the engine for economic growth in the region.[25]

Exhibit 37 below shows the growth and decline in employment in the Research Triangle MSA's clusters from 1990 to1999 (narrow cluster definition). The net gain in employment in traded industries over the period was 43,314 jobs. Especially fast-growing clusters include business services, education and knowledge creation, heavy construction services, distribution services, and financial services, while the largest loss in traded employment occurred in apparel, textiles, motor driven products, tobacco, and transportation and logistics.

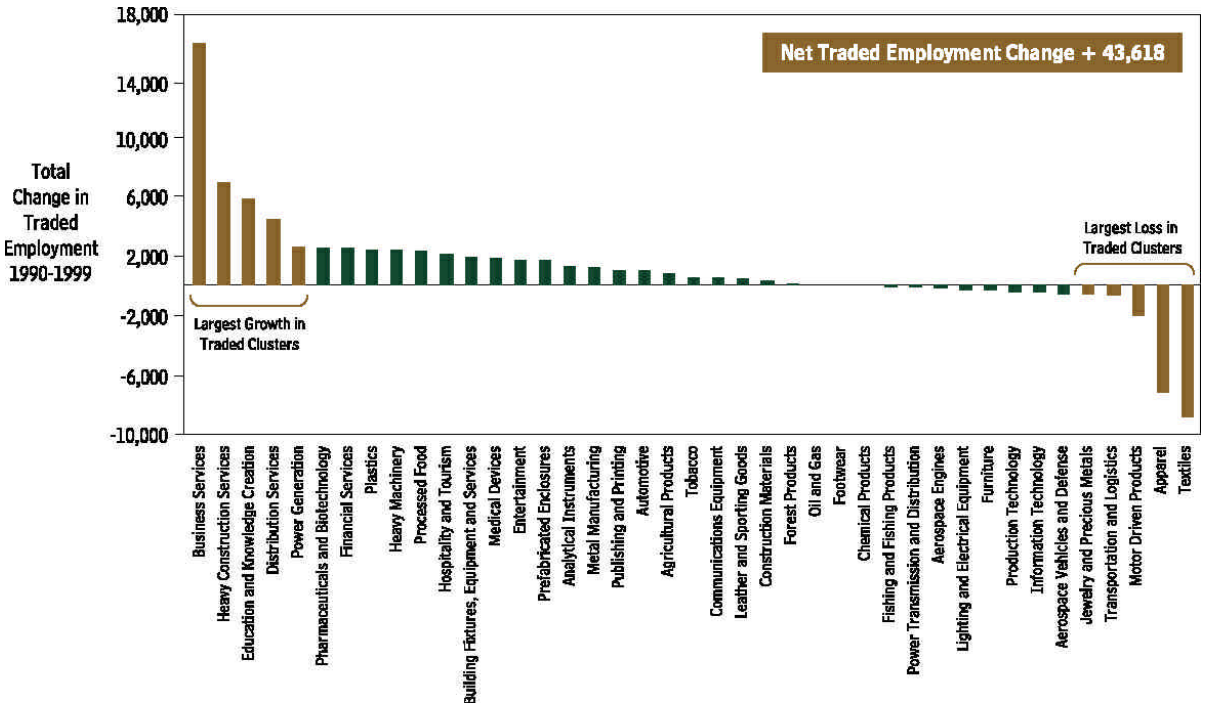
Exhibit 37: Job Creation by Cluster, Research Triangle MSA, Narrow Cluster Definition, 1990 to 1999



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

Exhibit 38 below shows the growth and decline in employment in the Research Triangle EA's clusters from 1990 to 1999 (narrow cluster definition). The net gain in employment in traded industries over the period was 43,618 jobs — only slightly more than the number of net gain in employment if measured as an MSA. Especially fast-growing clusters include many of the same as those for the MSA: business services, heavy construction services, education and knowledge creation, distribution services, and power generation (instead of financial services as in the MSA), while the largest loss in traded employment occurred in jewelry and precious metals, transportation and logistics, motor driven products, apparel, and textiles (leaving out tobacco, which was in the MSA's list of most jobs lost). One cluster in particular that fared much better in the EA is pharmaceutical / biotechnology. That cluster was the sixth fastest growing cluster in the EA, but only the tenth fastest in the MSA. The plastics cluster also exhibited similar characteristics.

Exhibit 38: Job Creation by Cluster, Research Triangle EA, Narrow Cluster Definition, 1990 to 1999



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

Exhibit 39 below shows employment and wage data from the leading clusters in the Research Triangle MSA (narrow cluster definition).[26] The fourteen red highlighted clusters are large and have been growing at or above the regional average. They have created 63.3% of the new jobs in traded industries in the Research Triangle from 1990 to 1999.[27] These fourteen clusters are the primary drivers of wealth creation in the Research Triangle MSA. Eleven clusters pay wages higher than the national average or are growing faster than the national average (highlighted in light blue).

This Exhibit again shows the innovative strength of the Research Triangle, with fourteen of the clusters having a higher per capita patenting rate than the national average, and sixteen increasing their patenting rate faster than the national average (highlighted in green).

Exhibit 39: Leading Clusters by Employment, Research Triangle MSA, Narrow Cluster Definition

Cluster	Total Employment 1999	Annual Growth Rate in Employment 1990–1999	Average Wages Indexed to Nation 1999	Annual Growth Rate of Average Wage Index 1990–1999	Patents per Employee Indexed to Nation 1998	Annual Growth Rate of Patent Index 1990–1998
Business Services	31,161	9.5	90	-1.6	95	3.2
Education and Knowledge Creation	30,668	2.5	136	3.0	121	14.0
Information Technology	21,515	-0.2	95	-1.4	52	11.1
Financial Services	10,985	2.4	N/A	N/A	172	16.9
Distribution Services	10,945	5.0	122	0.8	147	6.6
Communications Equipment	10,429	0.4	107	N/A	73	11.5
Heavy Construction Services	10,418	6.7	89	1.4	109	4.1
Hospitality and Tourism	9,312	2.5	91	2.1	175	22.8
Transportation and Logistics	6,227	-1.2	75	-3.4	180	36.7
Medical Devices	6,004	2.5	146	N/A	133	10.9
Processed Food	5,156	6.1	N/A	N/A	164	-5.4
Analytical Instruments	3,870	2.3	67	1.4	261	6.0
Textiles	3,811	-3.5	103	N/A	80	4.8
Publishing and Printing	3,000	3.1	88	2.3	206	2.6
Furniture	2,668	-1.1	107	N/A	24	-7.4
Entertainment	2,608	11.1	81	10.8	385	5.0
Building Fixtures, Equipment and Services	2,514	3.1	85	-0.6	91	-3.4
Pharmaceuticals and Biotechnology	2,477	9.4	98	N/A	191	-3.2
Production Technology	2,445	-1.0	N/A	N/A	244	11.8
Apparel	2,393	-7.9	74	N/A	169	10.7
Number of Clusters Outperforming National Average			6 / 17	7 / 11	14 / 20	16 / 20

Growing Faster Than National Average

Average Wages Higher or Growing Faster Than National Average

Number of Patents per Employee Higher or Growing Faster Than National Average

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

Exhibit 40 below shows employment and wage data from the leading clusters in the Research Triangle EA (narrow cluster definition). The fifteen red highlighted clusters are large and have been growing at or above the regional average. They have created 82.1% of the new jobs in traded industries in the Research Triangle from 1990 to 1999.[28] These fifteen clusters are the primary drivers of wealth creation in the Research Triangle EA. Eight clusters pay wages higher than the national average or are growing faster than the national average (highlighted in light blue). This Exhibit again shows the innovative strength of the Research Triangle EA, with ten of the clusters having a higher per capita patenting rate than the national average, and fifteen increasing their patenting rate faster than the national average (highlighted in green).

Exhibit 40: Leading Clusters by Employment, Research Triangle EA, Narrow Cluster Definition

Cluster	Total Employment 1999	Annual Growth Rate in Employment 1990–1999	Average Wages Indexed to Nation 1999	Annual Growth Rate of Average Wage Index 1990–1999	Patents per Employee Indexed to Nation 1998	Annual Growth Rate of Patent Index 1990–1998
Business Services	34,370	7.5	90	-1.5	105	7.6
Education and Knowledge Creation	33,106	2.2	136	3.0	113	13.5
Information Technology	21,628	-0.3	89	-1.4	52	11.1
Heavy Construction Services	15,162	7.1	85	1.5	75	1.5
Distribution Services	13,369	4.7	121	.9	128	5.5
Financial Services	12,945	2.4	69	-1.9	152	2.2
Textiles	12,852	-5.7	103	N/A	24	2.8
Hospitality and Tourism	11,888	2.3	89	2.4	137	20.0
Communications Equipment	11,616	0.6	107	N/A	66	10.9
Processed Food	11,168	2.6	97	-3.7	87	-.8
Apparel	9,694	-6.0	74	-1.1	42	-5.3
Pharmaceuticals and Biotechnology	8,501	4.0	98	N/A	53	1.9
Furniture	7,212	-0.4	71	N/A	14	-3.9
Transportation and Logistics	6,956	-1.0	75	-3.4	164	30.9
Medical Devices	6,819	3.6	146	N/A	123	9.0
Building Fixtures, Equipment and Services	6,014	4.4	81	-0.7	49	-3.8
Automotive	5,653	2.1	N/A	N/A	146	2.7
Plastics	5,355	6.9	75	N/A	118	4.0
Analytical Instruments	4,850	3.6	67	1.4	205	3.3
Prefabricated Enclosures	4,527	5.5	N/A	N/A	25	-4.7
Number of Clusters Outperforming National Average			5 / 18	5 / 12	10 / 20	15 / 20

Growing Faster Than National Average

Average Wages Higher or Growing Faster Than National Average

Number of Patents per Employee Higher or Growing Faster Than National Average

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

IBM and the Research Triangle. On April 4, 1965, IBM announced it was planning to build a 600,000-square-foot research facility on 400 acres in the Research Triangle Park.[29] Even though IBM owned land in several other states where it could have built a new facility, a number of very basic reasons drew the computer giant to the Research Triangle. Among them were the quality of life the area enjoyed, its reputation for having a high-quality work force, its proximity to outstanding universities, colleges, and community colleges, and the strong cooperative spirit between government, education, and the private sector.[30]

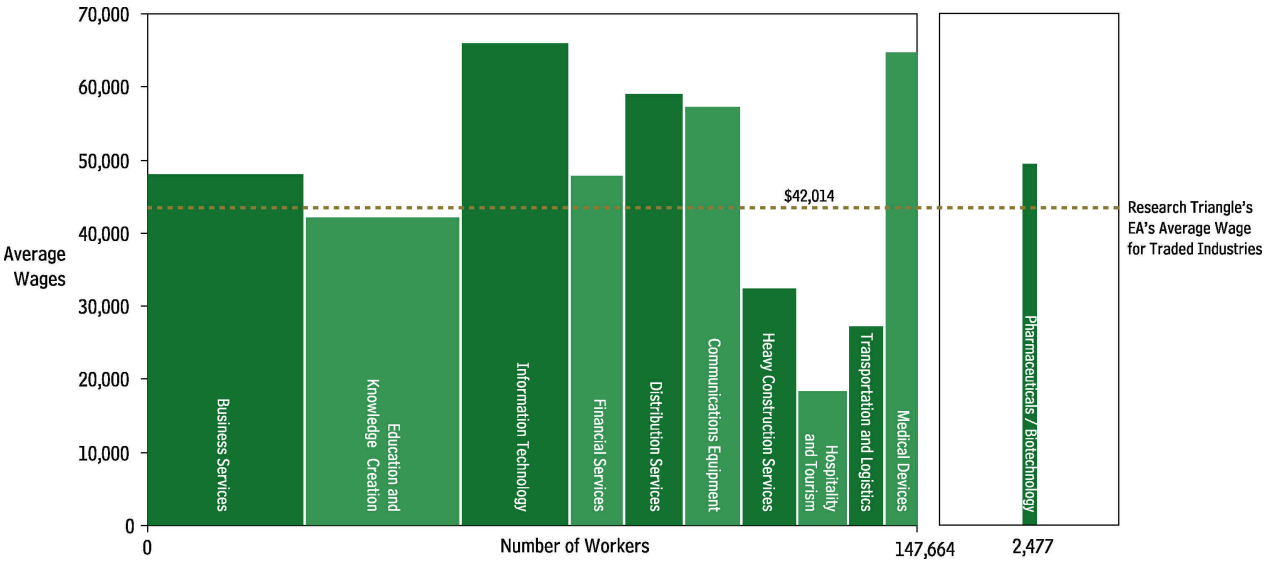
But there were additional reasons why IBM ultimately chose to invest in the region. The success of the Research Triangle Park as a research park hinged on an administrative decision made in the early 1960s – and it was not made at IBM's headquarters in Armonk, New York. A zoning agreement reached between the Research Triangle Foundation and Durham County opened the door to more manufacturing than had been allowed in the Park's first few years.[31] When the park opened in 1959, it was zoned to allow only research companies to locate there, but that made it difficult to attract tenants because the limitation to pure research was too restrictive for companies that wanted some sort of practical application for the research projects they conducted. Once a new zoning category was created—research applications—it allowed firms to manufacture products in the Research Triangle Park based on research conducted there.[32] Another incentive that made the Research Triangle Park location lucrative for IBM was a promise by then-Governor Dan Moore to link the Research Triangle Park, Raleigh, and Cary with a four-lane highway, which now exists in the form of Interstate 40.

Another reason why IBM has continued to expand in the region is logistics. Freight, duty, transportation, and getting products to market are critical in the PC business – IBM's Research Triangle Park facilities enjoy the lowest cost of getting the product to their customers of any of IBM's competing facilities.[33] As a result, during the 1960s and 1970s, IBM began transferring employees from New York, Minnesota, and Los Angeles. Ever since, the company has constituted about one-fourth of the park's square footage and work force. Although IBM went through a massive downsizing in 1993 to 1995, its Research Triangle Park work force survived almost unscathed. The Park had become the central location for the company's growing personal computer and networking operations, while its other sites struggled with products and services less in demand. To this end, the company has moved much of its product development from various parts around the United States to the Research Triangle, and they have also relocated a good portion of their headquarters functions from New York to the Research Triangle Park to enjoy the synergy that occurs between all of these functions.

It has been over 33 years since Thomas Watson Jr. heeded Governor Luther Hodges' sales pitch and opened a manufacturing plant at the Research Triangle Park. Since then, IBM has brought 37 different IBM organizations to the Research Triangle Park. Full-time employment at the Park has ranged from 10,000 to 11,000 during IBM's dark days of 1991 to 1994. Employment spiked to 13,000 in 1995 as operations shifted from Boca Raton, Florida, remaining more or less at that level ever since. Production employees now account for only 7% of IBM's full-time staff, with 45% of those workers being software or hardware engineers. Sixty-two percent of IBM's local employees were not working for the company here three years ago. As a result, IBM's Research Triangle Park facility is now one of its biggest in the world.

Exhibit 41 below shows the average wages in the Research Triangle MSA for the region's leading clusters (narrow cluster definition) for 1999. Ranked from highest total employment to lowest, information technology (third largest), financial services (fourth largest), distribution services (fifth largest), communications equipment (sixth largest), medical devices (tenth largest), and pharmaceutical / biotechnology (18th largest) show relatively high average wages compared to the other large clusters in the region.

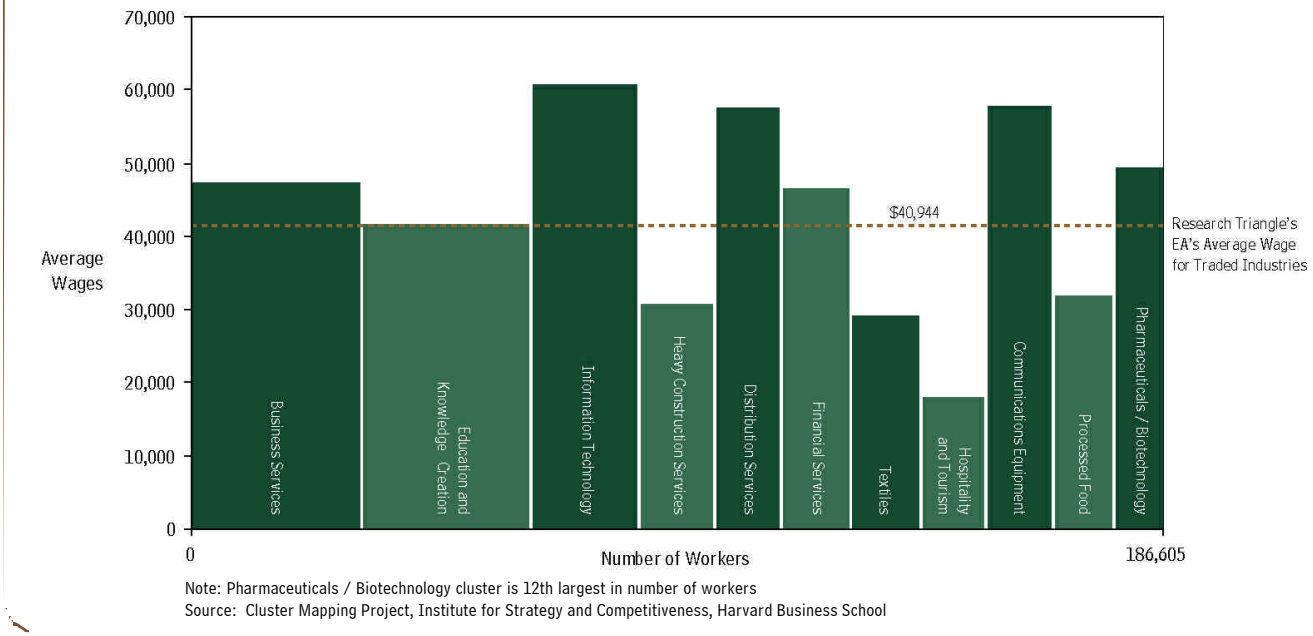
Exhibit 41: Average Wages for Leading Clusters, Research Triangle MSA, Narrow Cluster Definition, 1999



Note: Pharmaceuticals / Biotechnology cluster is 18th largest in number of workers
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

Exhibit 42 below shows the average wages in the Research Triangle EA for the region's leading largest clusters (narrow cluster definition) for 1999. Ranked from highest total employment to lowest, information technology (third largest), distribution services (fifth largest), communications equipment (ninth largest), and pharmaceutical / biotechnology (12th largest) show relatively high average wages compared to the other large clusters in the region, much like what occurs in the MSA.

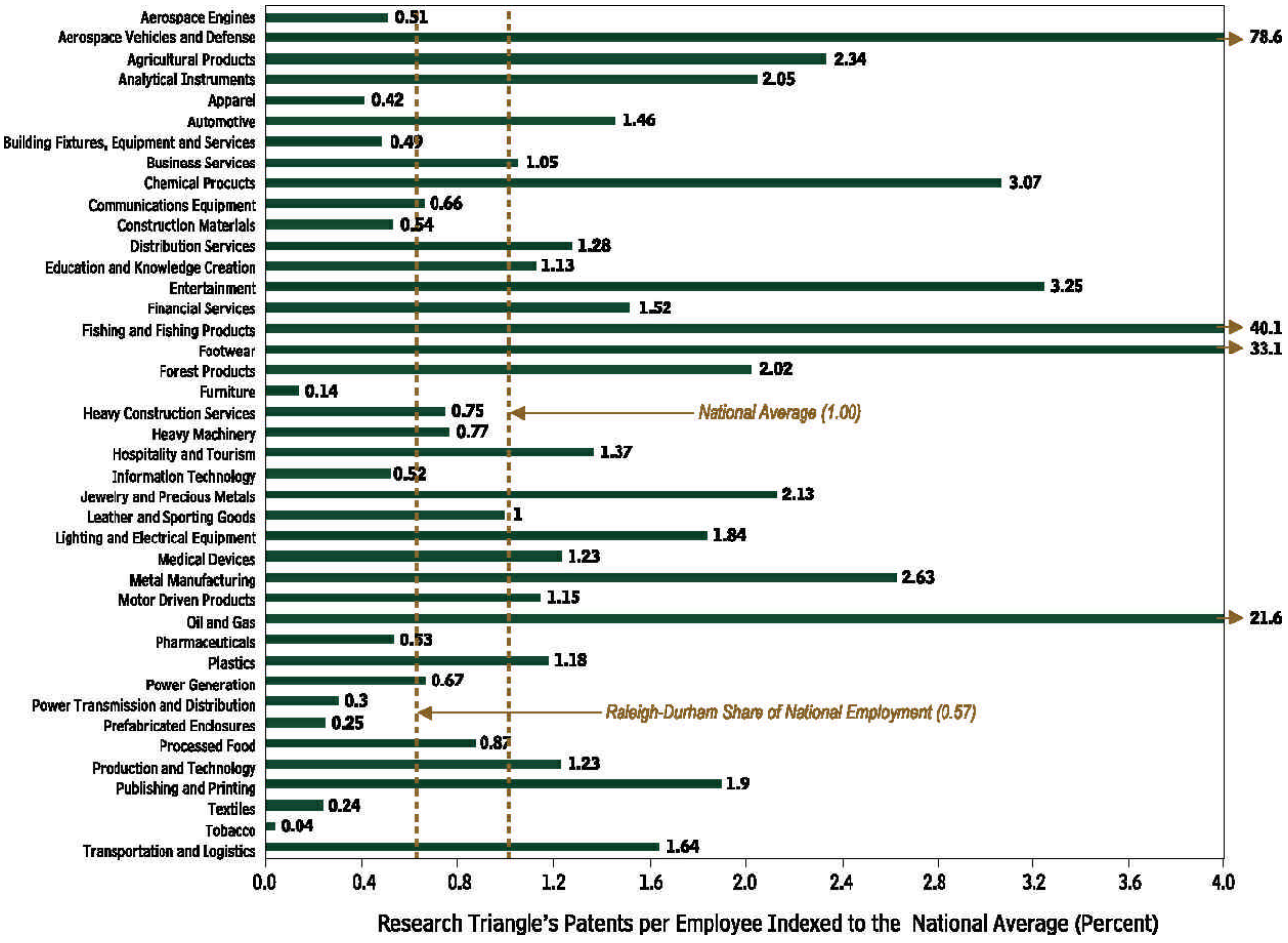
Exhibit 42: Average Wages for Leading Clusters, Research Triangle EA, Narrow Cluster Definition, 1999



Note: Pharmaceuticals / Biotechnology cluster is 12th largest in number of workers
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

When looking at patents per employee indexed to the national average by cluster in the Research Triangle EA (narrow cluster definition) for 1998, several clusters stand out, including aerospace vehicles and defense, fishing and fishing products, footwear, oil and gas, chemicals, agricultural products, entertainment, metal manufacturing, analytical instruments, and information technology. Low per capita innovation is present in textiles, apparel, furniture, and tobacco, mostly due to the high number of workers employed in these clusters vis-à-vis the number of patents issued. (See Exhibit 43).

Exhibit 43: Patents per Employee Indexed to the National Average by Cluster, Research Triangle EA, Narrow Cluster Definition, 1998



Note: National Average = 1.00
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

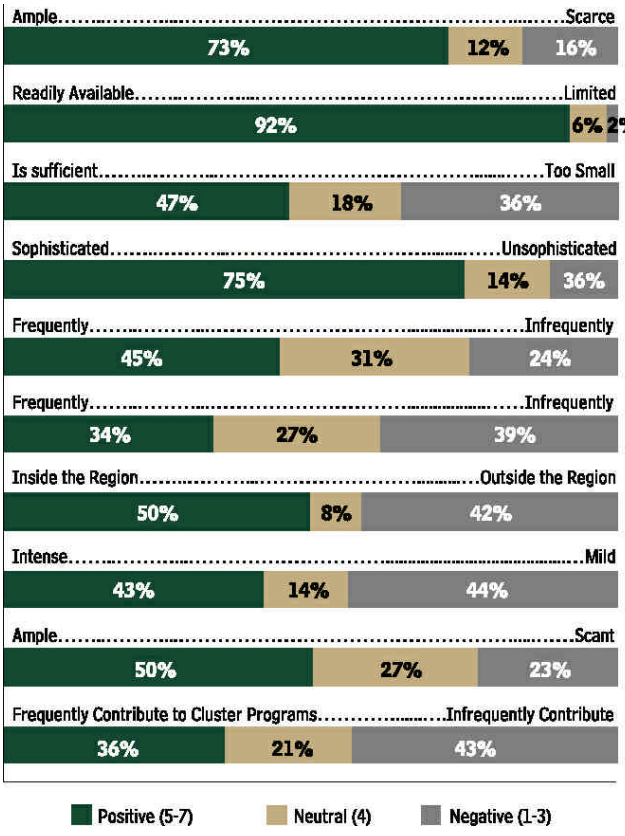
REGIONAL INNOVATIVE CAPACITY

For centuries, the Research Triangle economy has been significantly influenced by the tobacco and textiles industries. 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 key 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. The Research Triangle'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 commercialization of technology, the K-12 educational system, the focus on a limited array of clusters, the lack of large corporate headquarters, the collaboration among communities, and the collaboration within many clusters. 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. Exhibit 44 below shows select survey results from the Research Triangle regional economy that will be referenced throughout this section.

Exhibit 44: Select Survey Results, Research Triangle Regional Economy



Factors Inputs

- Qualified scientists and engineers in your region are . . .
- Specialized facilities for research are . . .
- The available pool of skilled workers in your region is . . .

Demand Conditions

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

Related and Supporting Industries

- Regional specialized suppliers assist your firm with new product and process development . . .
- Specialized suppliers of your business' materials, components, machinery, and services are mostly available. . .

Rivalry

- Regional competition in your industry is . . .

Government

- State and local government support for investment in R&D (e.g., funding business incubators, creating consortia) is . . .

Attitudes

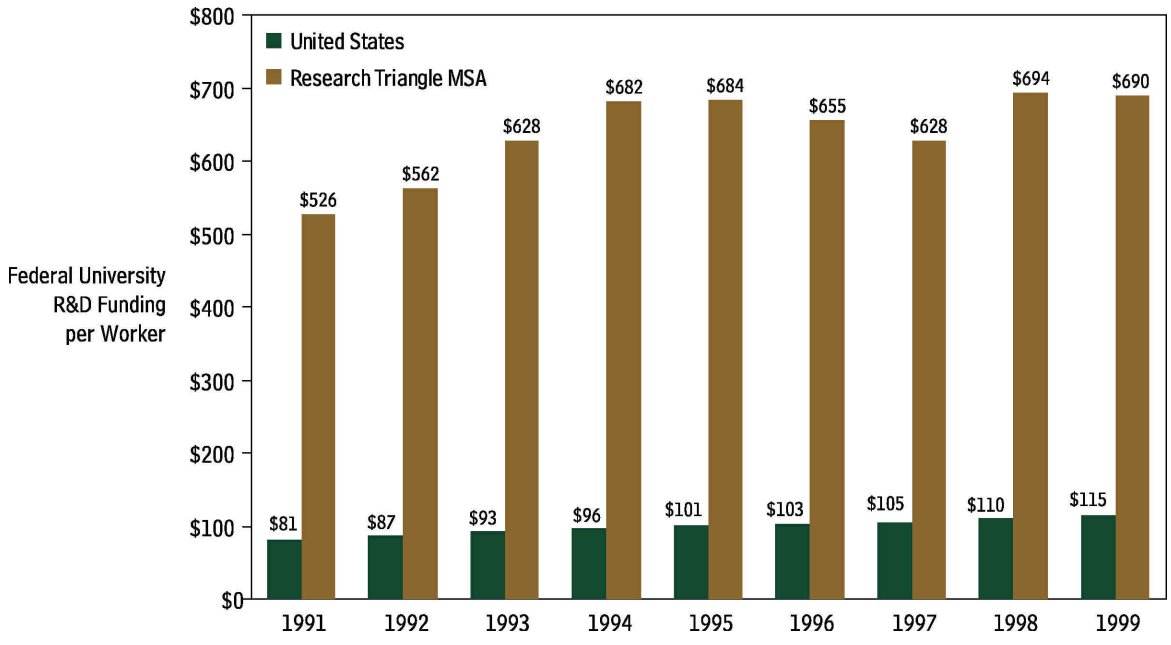
- Firms and organizations in your cluster . . .

Note: August 2001, n=116
Source: Clusters of Innovation Initiative Regional Survey

Basic and Specialized Factor Inputs

Investment in Research and Development. The Research Triangle's leaders have been successful in attracting research institutions to the region, with the region having more than ten major specialized research centers. A good indicator of the level of local investment is federal R&D expenditures to universities. Standardizing by the number of workers, the Research Triangle consistently receives more than six to seven times the national average of R&D investment per worker (See Exhibit 45).

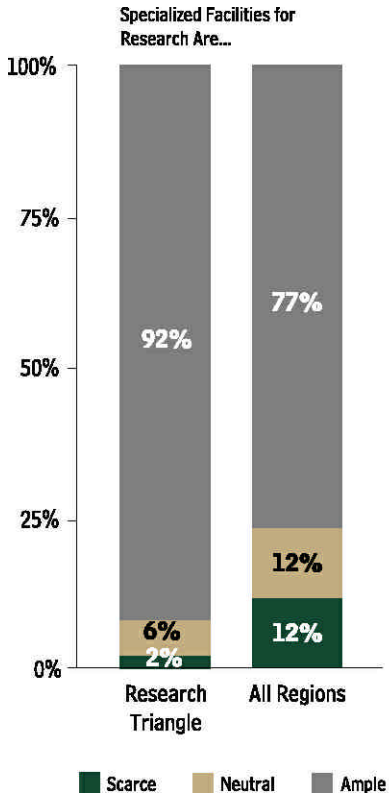
Exhibit 45: Federal Expenditures for University R&D per Worker, Research Triangle versus U.S., 1991 to 1999



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

Ninety-two percent of those surveyed reported that local research centers were readily available to support research and development needs (versus 77% across other regions), and 68% said they frequently transferred knowledge to the private sector (see Exhibit 46).[34] As mentioned by a director at a major local research institution, "The Universities, especially North Carolina State University, have a long history of working closely with business (due to their roots in the old land grant system). This is very clearly reflected in the innovative approach used to build the Centennial Campus where businesses were invited onto campus to help build new buildings etc., sometimes as speculative investments."[35]

Exhibit 46: Select Survey Results and Representative Quotes, Specialized Research and Training, Research Triangle



SPECIALIZED RESEARCH AND TRAINING

"Community colleges are very strong in the region and they tend to focus on tech training, which is unusual since many community colleges focus on transitioning students from high school to four-year colleges."

- Economic Development Official

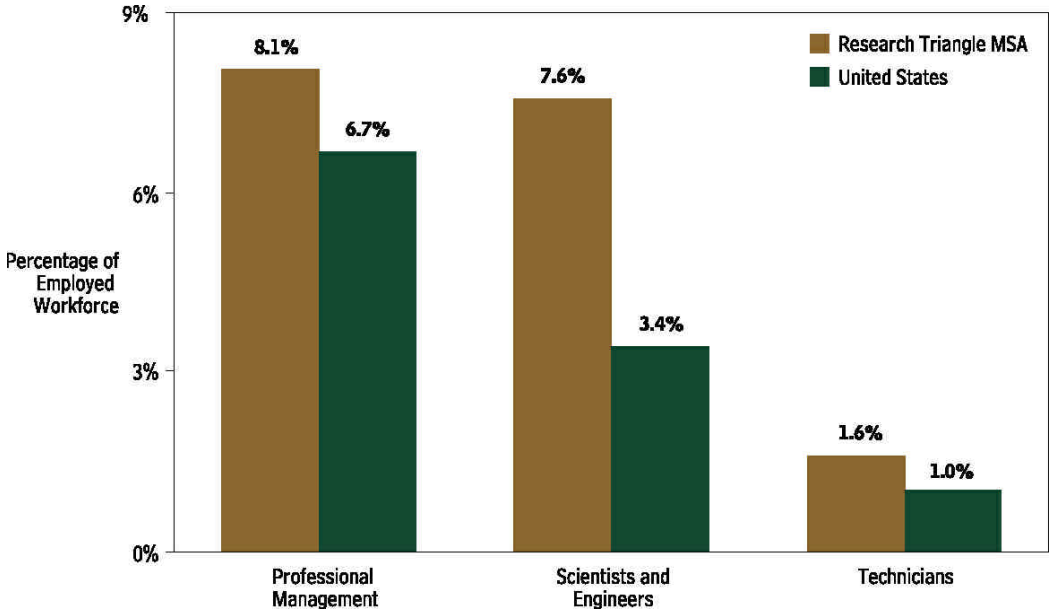
"The universities are really making a big push now to churn out viable companies out of their specialized research facilities. There is a noticeable change in the way they are thinking about the ideas created by their institutions."

- Communications CEO

Note: August 2001, n=116
Source: Clusters of Innovation Initiative Regional Survey

Skilled Workforce. Exhibit 47 shows that the Research Triangle has a relatively large number of scientists, engineers, and skilled technicians. Surveys and interviews also indicate that many firms came to the Research Triangle because of the labor pool. For example, 72.5% of our survey respondents indicated that there was an ample supply of qualified engineers and scientists in the region, versus 52.7% in the other regions and first among all five regions studied. Other surveys point to similar conclusions, including one showing that the Research Triangle had 34.8% of adults 25 years or older with a bachelor's degree or higher (the fourth highest on a list of selected MSAs) versus Dallas (the second highest at 27.6%), and Charlotte (at 19.6%).[36] Another survey shows that by 2005, computer scientists, computer engineers and systems analysts will account for three of four of the fastest growing occupations in the state.[37]

Exhibit 47: Percentage of Total Workforce by Select Professions, Research Triangle MSA vs. U.S., 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, National Sciences and Related Occupations, Computer, Mathematical, Operations Research, and Related Occupations, Economists
Technicians includes: Technicians and Technologists in Scientific and Engineering Related Occupations
Source: U.S. Bureau of Labor Statistics, Occupational Employee Statistics

In 1998, the region produced approximately 1% of the total U.S. advanced and bachelors degree holders in the hard science and engineering fields.[38] In that year, the Research Triangle had 0.91% of the nation's scientists, engineers, and related technicians; it had 0.53% of the nation's upper level scientists and engineers.[39] This data supports feedback commonly expressed in surveys and interviews that that the region will not have particular trouble replenishing its pool of scientists, engineers, and technicians. Forty-six percent of survey respondents stated that the available pool of skilled workers in their region was sufficient to meet their growth needs, versus 53% for other regions.

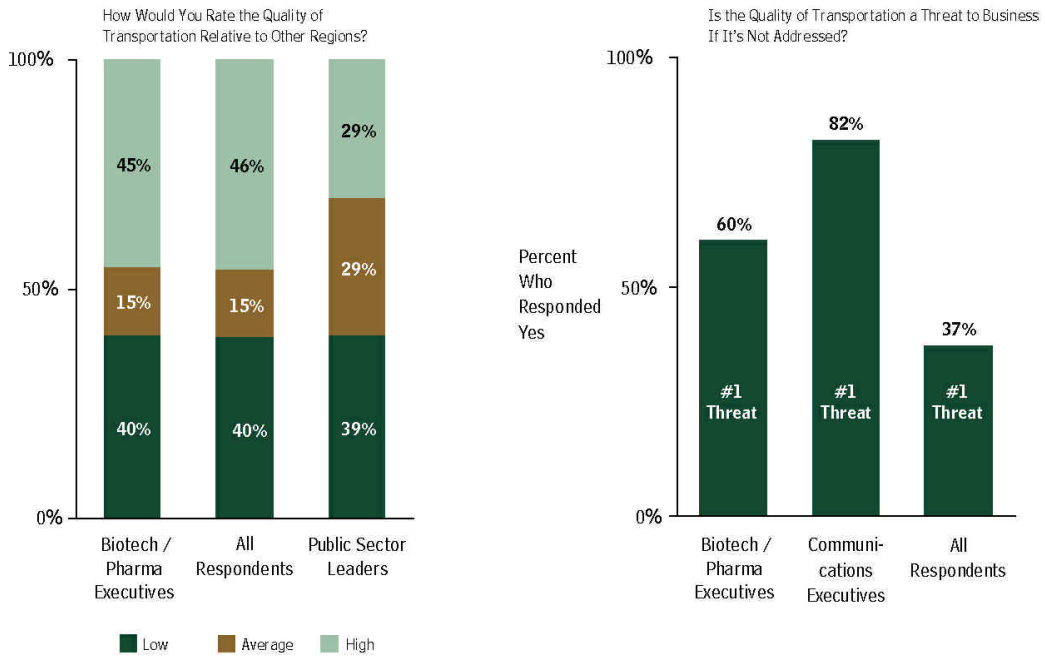
Another strength — as indicated by survey respondents and interviewees — is that not that many firms must recruit managers and marketers from outside the area. Forty-six percent of survey respondents in the Research Triangle indicated that the available pool of skilled workers in the region was sufficient to meet their growth needs, versus 37% across all regions. Professional management makes up 8.1% of the Research Triangle's workforce, better than the 6.7% of the United States' workforce, but lagging Austin's 9.6%. Even with these relatively good numbers, the region must continue to be vigilant when it comes to providing local talent to area-companies, specially the smaller businesses. As one local educational leader put it, "A major concern for smaller companies is whether the region can grow them a workforce. They are usually unable to grow one themselves and so rely on the state and local governments to supply them skilled labor."[40]

Quality of Education. The quality of K-12 education in the Research Triangle appears to be at, or slightly below, national averages. Between 1998 and 1999, the Research Triangle's graduation rate of 82.5% exceeded the state average of 81.4%, but not the national average of 82.8%.[41] Since 1990, the Research Triangle student's SAT scores have been slightly lower than the national averages, with the Research Triangle averaging 994 and the nation averaging 1016 (out of 1600 total possible) in 1999, but ahead of North Carolina's 986.

Deficiencies in K-12 education affect the competitive environment of companies by making it harder to recruit people to the area. As mentioned by an executive at a leading communications equipment company, "One of the biggest recruiting issues we have is the quality of the K-12 education in the area. The local governments need to increase taxes to deal with the K-12 issue as well as related issues that exist."[42] A respected educational official adds, "Some necessary investments are not being made. For example, infrastructure in the Park, such as adult education, is sorely lacking, yet there is little being done to address these deficits. The region needs a drastic improvement in its own basic K-12 education."[43]

Physical Infrastructure. The Research Triangle has an above-average communications infrastructure (87.9% of survey respondents said it satisfied their business needs, versus 80.7% across all regions). Air transportation, however, is a problem. Although the Raleigh-Durham International Airport is centrally located and modern, it lacks both frequent and direct flights to many destinations. Population and economic growth will create increased demand for air transportation. The recent bankruptcy of the only locally based air carrier, Midway Airlines, only exacerbates the problem. A number of biotechnology and communications equipment firms now anticipate increased need for air transport as their products become

Exhibit 48: Select Survey Results, Physical Infrastructure, Research Triangle



Source: Clusters of Innovation Initiative Regional Survey

ready for commercial distribution. As one biotechnology CEO noted, "The venture capital community does not like to be far away from their investments. If they have to fly in from San Jose or Boston, they want the flight to be direct and with high frequency. If your company grows beyond a certain size, direct and frequent flights to international centers of business are also critical if it's going to attract the right type of investors and clients."[44]

A second issue is road congestion and ineffective public transportation. This issue was repeatedly cited in interviews as being detrimental to the quality of life in the region. Overall, 60% of biotechnology survey respondents, 82% of communications equipment executives, and 37% of all survey respondents cited the quality of transportation as a threat to business if it is not addressed. In fact, in all three respondent groups the quality of physical infrastructure was ranked as the number one threat facing the region. (See Exhibit 48 on previous page).

Some steps have been taken to alleviate the problem, including the formation of the Smart Commute @ the Research Triangle Park committee by the Research Triangle Park Owners and Tenants Association in January 1999 to help companies find ways to reduce the number of cars on area roads. The impetus for creating the committee developed in 1998, when the heads of several major companies in the Research Triangle Park met with Governor Jim Hunt and then Transportation Secretary Norris Tolson to discuss traffic problems at the park.

In 1999, the committee released the results of a study detailing the commuting patterns of park employees. Companies responding to the survey employ 41,070 people, including 10,710 who work in buildings adjacent to the park. More than 20,000 of all employees, or 51%, commute from Wake County. Another 8,192 people (21%) commute from Durham County, while 3,127 (8%) come from Orange County and 8,046 (20%) commute from other nearby counties. According to the study, 73% of these commuters are office workers, 14% are 'anchored,' meaning they must physically be at their work site in order to do their jobs, and 10% work in manufacturing, jobs that also require their physical presence. The remaining 3% represent travelers or those who are in transit from one company site to another. The study also pointed out that 90% of the Research Triangle Park commuters drive to work in their own cars during peak hours, and that only 3% use car pooling or van pooling and less than 1% use mass transit or other modes of transportation such as bicycles.

According to the report, the committee is focusing on five alternatives to single occupancy vehicles: car pools, van pools, mass transit, cycling, and telecommuting. Some companies are actively promoting car pooling, but with limited success. At the moment, only 1% of Nortel employees are in car pools. Also, the committee's numbers are slightly misleading in that the study focused only on those who telecommute from home on a full-time basis. The telecommuting numbers are higher at companies like Nortel, which has a formal telecommuting program and a special telecommuting coordinator. Ridership on Triangle Transit Authority busses and shuttles has shown a steady increase, with some organizations, mostly the United States Environmental Protection Agency and the National Institute of Environmental Health Sciences, subsidizing all or part of their employees' ridership.[45]

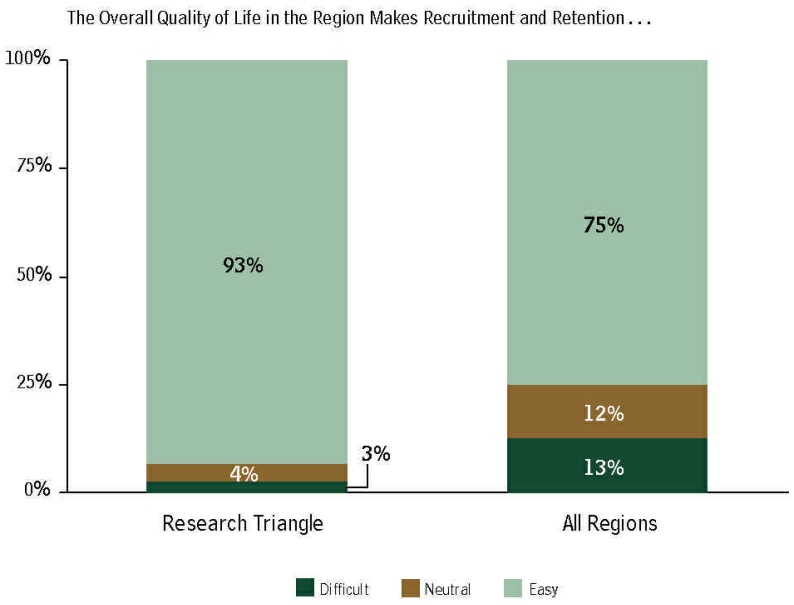
Supply of Risk Capital. Although local risk capital is much more plentiful in the Research Triangle than five years ago, it is not abundant. Survey respondents report that capital is somewhat ample, with 40.7% saying it satisfied their needs, versus 42% across the other regions. Interviewees are also split between those reporting adequate versus inadequate funding. Some interviewees suggested that perhaps

the region could benefit from closer cooperation with the Charlotte-based financial community. As mentioned by one communications equipment executive, "The proximity to Charlotte's finance resources is something that hasn't been explored that well. It's right down the road and the Research Triangle is the closest research center to this financial center."[46] The fact that there are a relatively high number of Fortune 500 companies based in Charlotte, as well as a good number of Forbes 400 richest Americans, indicates a good, nearby source of risk capital.

Quality of Life. Interviewees consistently state that the Research Triangle's quality of life has been a significant positive asset helping to develop the economy. Its location near the mountains and North Carolina's beaches, relatively mild winters, small-town feel, business-friendly attitude, and close proximity to Atlanta and Washington, DC, make the Research Triangle 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, with 93% of respondents citing it as a positive attribute in recruiting companies to the region, versus 75% of respondents across all regions (see Exhibit 49).

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. If average wages fail to keep up with or surpass any increases in the cost of living, then the region's historical advantage in this factor will steadily decrease. It is not clear that this historical asset will remain the strong attraction it has been in the past.

Exhibit 49: Select Survey Results, Quality of Life, Research Triangle



Source: Clusters of Innovation Initiative Regional Survey

The Role of Government

Government actions — by federal, state, or local agencies — affect innovation through their influence on elements of the diamond. Exhibit 50 summarizes the most important government influences on the Research Triangle economy.

Exhibit 50: Government Impact on the Determinants of Regional Productivity

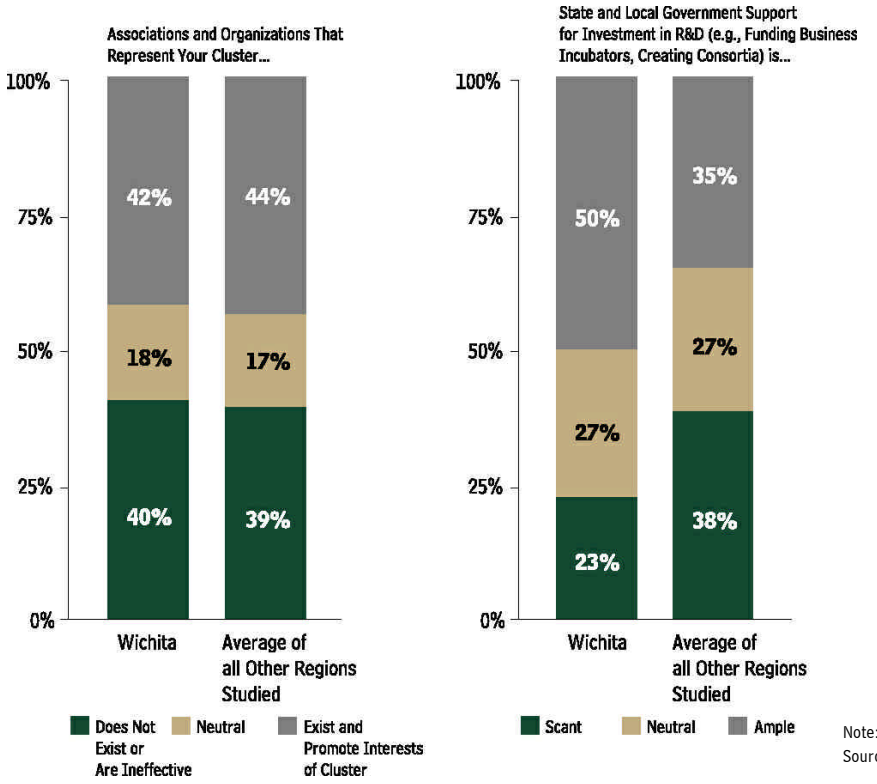
Element of the Diamond	Federal Government	State Government	Local Government
Factor Inputs	+ High levels of R&D funding (e.g., U.S. EPA and NIH)	+ Founded UNC & NCSU + Funds Community Colleges + Increasing funds for engineering school, NC Board of Science & Tech − Average K-12 education	+ Zoned RTP for research + Provided land on favorable terms (e.g., RTP) − Lack of coordination and leadership prevents maintenance and improvements of infrastructure (e.g., roads, schools, airport)
Demand Conditions	+ U.S. EPA and NIH are sophisticated customers of biosciences technology	− State FDA regulations different from Federal FDA regulations + State's Information Highway project encourages use of communications grid	Not mentioned
Related and Supporting Industries	Not mentioned	− Lack of recruiting focused on clusters	− Lack of recruiting focused on clusters
Context for Firm Strategy and Rivalry	+ Technology spill-over focused on civilian markets	− Inadequate state tax incentives to encourage R&D investment	− Inadequate local tax incentives to encourage R&D investment

Source: Clusters of Innovation Initiative Regional Survey™ and Interviews

The most positive governmental impact has been the upgrading of factor inputs. Local and state efforts brought information technology and bioscience research and training facilities to the Research Triangle; 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 the Research Triangle's economic success. As one economic development leader mentions, "There is still some kind of Southern model of cooperation in place. The 'old boy's network' in this state actually works to its advantage. A small number of influential leaders can actually make a big difference in the State because of the power they wield."[47] A second positive influence has been the National Institutes of Health's and the United States Environmental Protection Agency's demand for biosciences technology. The United States Environmental Protection Agency and the National Institutes of Health were two of the most sophisticated consumers of this technology, and without them, the Research Triangle biosciences cluster might never have emerged.

Fifty percent of Research Triangle's survey respondents indicated that state and local government support for investment in R&D (e.g., funding business incubators, creating consortia) is ample versus 35% across all regions. Exhibit 51, on the following page, highlights these results.

Exhibit 51: Research Triangle, Selected Survey Results



Note: August 2001, n=116
Source: Clusters of Innovation Initiative Regional Survey

The main negative effect of government concerns the maintenance of quality factor inputs. State actions contribute to a poor transportation infrastructure, average K-12 education, and high costs for licensing facilities. Poor coordination by local governments makes it difficult to solve infrastructure issues like upgrading roads, schools, and the airport. As one local political leader mentioned, "There are too many governments — twenty plus municipalities for only one million people leads to a lack of regional cooperation and planning. They don't go to the state with one voice. In addition, there is also a lack of action by businesses because the problems aren't really big enough to warrant their action — though that is changing."[48]

Such jurisdictional paralysis has become more commonplace, although exceptions do exist. For example, development of airport, port, and rail facilities are the responsibility of limited-purpose special authorities — the Research Triangle Airport Authority, a public body made up of officials from the cities of Raleigh and Durham as well as Durham and Wake counties—not centralized city agencies, as is the case in Los Angeles, San Francisco, and Seattle. Regarding air transport, the Airport Authority has jurisdiction over the Raleigh-Durham Airport, and the Triangle Transit Authority (TTA)—a regional public transportation authority serving Durham, Orange, and Wake Counties which finances regional bus operations, ridesharing programs and planning programs— is responsible for regional planning.

A 13-member Board of Trustees governs TTA. Ten members are appointed by the region's principal municipalities and counties and three members are appointed by the North Carolina Secretary of Transportation. There is also the Durham/Wake County Research and Production Service District, the

organization that enforces the covenants and oversees the amenities for the two counties. The district was created by the North Carolina legislature in 1980, and by state law, the district is protected from annexation by any municipality. The Durham/Wake County Research and Production Service District also acts as a liaison between the Research Triangle Park companies and local municipalities, helping them with planning and permits.[49] Even so, progress on infrastructure issues is often perceived of as being too slow, and there are several proposals being discussed that could consolidate authority over transportation planning and decision-making beyond the slew of current entities.

Raleigh-Durham Airport. Next to the birth of the Research Triangle Park, many business leaders hold the creation of the Raleigh-Durham airport up as the key driver to the Triangle's expansion over the past few decades. Wake and Durham counties and the cities of Raleigh and Durham joined forces in 1940 to buy almost 900 acres in western Wake County for an airport that could replace a smaller facility south of Raleigh. The Army Air Corps used the airport as a base during World War II, but returned the facility — now 400 acres larger and filled with infrastructure — to local authorities in 1946.

It did not hurt that the charismatic chief of Eastern Airlines, Capt. Eddie Rickenbacker, met in turn with both cities' chambers of commerce to emphasize cooperation on a regional airport venture. The Raleigh-Durham Airport expanded slowly but steadily over the next four decades, then started booming in the late 1980s when American Airlines established a hub there.[50]

American dismantled the hub by 1994, with Midway Airlines, taking over as the region's largest carrier. Unfortunately, several interviews pointed to the fact that there are not enough flights to several key cities where customers, venture capitalists, and others are based. Exacerbating the situation, Midway Airlines filed for Chapter 11 bankruptcy in August, 2001, effectively putting its large operations in the area at risk. As a result of the disruption of air service on September 11th, Midway Airlines suspended operations on September 12th, 2001. After a direct government grant of $10.5 million dollars, Midway re-launched service from RDU on December 19, 2001 to six cities.[51]

Added to this increasing level of complexity is the region's aforementioned "digital divide". Recent studies, like the United States Commerce Department's Falling Through the Net, report that North Carolina ranks 45th among the states in households with computers and 46th in the percentage of households using the Internet. In fact, rural subscribers in North Carolina pay roughly $230 per month for a 128K Internet connection compared to $50 per month in the state's urban areas, according to a study by the state Department of Commerce's Office of Information Technology Services.[52]

As a director of a leading research institution mentions, "The assimilation of newcomers is always difficult. The region's strong growth has dragged a large number of newcomers into the region, and this has created problems with the dilution of existing culture and transportation issues. There is also the potential for rural versus urban divide. The poor rural communities continue to feel that they have not benefited as much as other regions from the State's success."[53] To tackle this problem, the North Carolina General Assembly approved the creation of the Rural Internet Access Authority in 2000 to oversee efforts to provide rural areas with high-speed broadband Internet access. The authority's main goals are ambitious: to provide local dial-up Internet access from every telephone exchange in North Carolina within

one year; and to provide high-speed Internet access at competitive prices (at least 128K for residential customers and at least 256K for business customers) to all North Carolinians within three years. The authority is governed by a 21-member commission, which includes members of state government, business and education leaders, members of the Microelectronics Center of North Carolina and representatives from the state's telecommunications companies, including Internet service providers, rural telephone cooperatives, local telephone exchange and independent telephone companies, commercial wireless communications carriers, and the cable industry.[54]

Nevertheless, the digital divide, and the urban versus rural differences came up time and time again during interviews and should be included in a list of topics ripe for regional coordination. As noted by one educational leader, "Counties bordering the Research Triangle region have half the average wage and five times the jobless rate. Clearly, this imbalance will not be tolerated for too long. Local government needs to avoid a situation where other regions begin demanding transfer payments of some sort, especially given the region's reliance on state-funded education."[55] Given the strong political power base of North Carolina's rural communities, tackling this issue might prove very difficult for the Research Triangle. As the same educational leader adds, "Rural interests are powerful and they are not necessarily sensitive to urban problems."

Ultimately, local business leaders have an increasingly important role to play vis-à-vis the traditional regulatory entities. Several interviewees mentioned that there was a definite lack of coordination among business stakeholders to spur government to act on their concerns. The exemption has been the recent addition of a direct flight between Raleigh-Durham Airport and San Jose International Airport in California. As noted by one communications equipment executive, "Big companies need to be more proactive about affecting change. The politicians aren't going to come to them. Companies must work a bit harder. An example was that as soon as IBM and Cisco started talking louder about a direct flight to San Jose, it got done. Perhaps officials had not acted on that before because they had not realized that those two companies constituted 70% of business flights and 35% of the total demand for the route."[56]

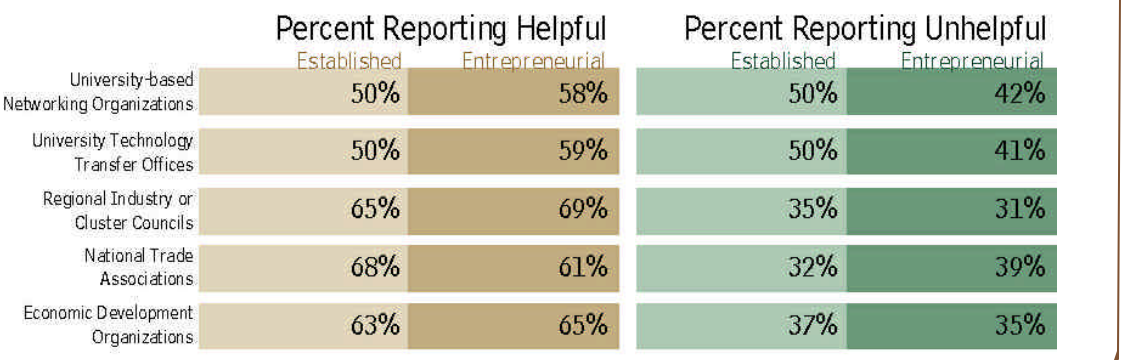
Regional Institutions for Collaboration

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. Ninety-two percent of survey respondents in the Research Triangle indicated that specialized facilities for research (e.g., science laboratories, university research institutions and technical libraries) are readily available, versus seventy-six percent across all regions. As one economic development leader notes, "The Centennial Campus is the model for the future. The classroom is right on top of business, causing informal networking to increase exponentially in a robust off-line social environment. Its like a company town for the 21st century."[57] Efforts at replicating the success of the Centennial Campus have been under way during the last couple of years, including the development of the Horace Williams Campus at the University of North Carolina-Chapel Hill, and the Millennial Campus concept throughout the University of North Carolina system.

Forty-two percent of survey respondents in the Research Triangle indicated that associations and organizations that represent their cluster exist and promote the interests of the cluster, versus 44% across all regions. Sixty-eight percent of Research Triangle respondents indicated that these institutions frequently transfer knowledge, versus 53% across all regions. There were virtually identical responses in the Research Triangle region versus across all regions when survey respondents were asked if firms and organizations in their cluster treat new companies as full partners.

When respondents are delineated as entrepreneurs versus established companies, the consensus among established companies is that the region's institutions for collaboration are, in general, less helpful for them than they are for entrepreneurs (see Exhibit 52 below).

Exhibit 52: Institutions for Collaboration Survey Results, Research Triangle Region



Source: Regional Survey Data

In the late 1950s, the knowledge and human resources necessary to build many business clusters existed in the Research Triangle, but were not being developed to their full potential. The scientists and engineers who possessed commercially viable research ideas lacked business skills and access to risk capital. Furthermore, these resources were scarce in the Research Triangle. The Research Triangle Institute, founded in 1958 in conjunction with the Research Triangle Park, was among the first regional institutions for collaboration to positively affect the situation. Shortly after its founding, the Research Triangle Institute became a place that gathered business know-how, and brought together researchers, entrepreneurs, and investors.

Research Triangle Institute. The Research Triangle Institute, which now numbers more than 1,800 employees, really came to life when the local universities transferred their Institute of Statistics to the Research Triangle Institute. The Institute's early plans included research work in diverse sciences, including chemistry research that sought cancer drugs from natural sources. In the 1960s the Research Triangle Institute received a generous grant from the Camille and Henry Dreyfus Foundation to establish a polymer research laboratory. Next, the Research Triangle Institute established a solid-state laboratory, which did some of the pioneering work on silicon technology.

The laboratory was the precursor of today's electronic systems and semiconductor research at the Institute. As public and government interest in environmental protection grew in the 1960s, so did related programs at the Research Triangle Institute, building on capabilities in statistical, physical, and life sciences. Current clients of the Research Triangle Institute include domestic and international private and public sector organizations in the areas of health and pharmaceutical, environment, education and training, technology commercialization, and decision support.

More than 80 percent of the Research Triangle Institute's work comes from the federal government. Their largest single project is the National Household Survey on Drug Abuse and the National Teen Smoking Survey, a five-year, $200 million contract. In 1999, the Research Triangle Institute completed more than 50 projects for pharmaceutical companies and the Food and Drug Administration / the National Institutes of Health. Interviewees consistently rated the Research Triangle Institute high among regional institutions for collaboration.

In more recent times, additional institutions for collaboration have been created to help the region bridge geographical distances and align economic development efforts along a more broadly defined MSA. One of these is the Research Triangle Regional Partnership. In many ways, the Research Triangle Regional Partnership represents the region's way of tackling the perceived notion that there is no effective regional coordination. While the Research Triangle Regional Partnership certainly helps this coordination, it might not be enough to head off longstanding tendencies. As one local economic development leader points out, "We need to regionalize the discussion. There is a regional economy, but the political and social jurisdictions tend to be more parochial. As a result, there is no 20 year vision and no agreement on what the region should look like."[58]

The Role of the Research Triangle Regional Partnership. In 1990, community leaders from Raleigh, Durham, and Chapel Hill met and decided to market their communities together. By regionalizing their efforts, the area could emphasize the strengths that each individual community had while pulling on the appeal of the entire area. Thus, the Raleigh-Durham Association, which was funded by the Raleigh-Durham-Chapel Hill Chambers of Commerce and the Research Triangle Foundation, was created and incorporated in 1990. The goal of the organization was to market the counties of Wake, Durham, and Orange for the economic benefit of its communities.

In 1993, an executive director was hired to manage the association, the scope was expanded to a six county MSA, and the organization changed its name to the Raleigh-Durham Regional Association. These counties included Chatham, Durham, Franklin, Johnston, Orange, and Wake. Also in 1993, regional marketing organizations were operating in the Charlotte region and the Greensboro/Winston-Salem/High

Point (Piedmont Triad) region of North Carolina. The state government decided that a more regional approach would be more advantageous, so the General Assembly subsequently formed seven regions throughout the state in 1994. At that time the Raleigh-Durham Regional Association expanded again to 13 counties and changed its name to the Research Triangle Regional Partnership in November of 1994.

The Research Triangle Regional Partnership, considered by many interviewees to be the premier regional marketing organization, assists corporate real estate executives and site selection consultants interested in locating or expanding a business to the Triangle region. The Research Triangle Regional Partnership is consistently cited by interviewees as being one of the region's most helpful institutions of collaboration.

In addition to the formal organizations of the Research Triangle Institute and the Research Triangle Regional Partnership, many informal institutions developed in the 1980s and 1990s that proved instrumental in connecting individuals in the business, academic, and government communities in the Research Triangle. Interviews reveal important informal groups created in companies like IBM and GlaxoSmithKline and in labs like the North Carolina Biotechnology Center and Duke University Medical Center. These groups also helped entrepreneurs access scarce capital and business knowledge.

Finally, prior to the 1990s, the Research Triangle had a reputation as being a place where it was difficult to start a business, and where there were relatively few employers. This made it difficult to recruit outside talent. More recently, several well-regarded institutions for collaboration have established themselves as first-class regional players:

- The Council for Entrepreneurial Development was founded in 1984 to stimulate the creation and growth of high impact companies in the greater Research Triangle area. The Council for Entrepreneurial Development achieves its mission by providing programs and services in four major areas: education, capital formation, mentoring, and communications. The Council for Entrepreneurial Development is a private, non-profit organization with more than 4000 active members representing 1180 companies and is the largest entrepreneurial support organization in the U.S. Many of the executives who were interviewed, cited the Council for Entrepreneurial Development as an example of an organization which is instrumental in helping local entrepreneurs, investors, service professionals, academicians, researchers, and public policy makers combine their efforts. In fact, the Council for Entrepreneurial Development received the most consistently positive praise out of all the institutions for collaboration named in the interviews.
- The North Carolina Biotechnology Center was established in 1981 by the state General Assembly as a private, non-profit corporation to assist science, education, business, and government along the path from idea to commercialization. The Center, which is the nation's first state-sponsored biotechnology initiative, does not conduct laboratory research. The North Carolina Biotechnology Center is a regional organization often cited by interviewees as critical for the success of pharmaceutical / biotechnology start-ups.
- The Centennial Campus is North Carolina State University's "technopolis," a mix of university, corporate, and government R&D facilities and business incubators currently being developed with plans for a town center, executive conference center and hotel, housing, and recreational facilities. This 1,334-acre site, adjacent to North Carolina State University's main campus, separates buildings into R&D neighborhoods with multidisciplinary themes based on the University's strengths in advanced research and client-driven training programs: advanced communications technologies,

biosciences and biotechnology, advanced materials, environmental technologies, and pre-college education. The campus, which is currently being developed and is home to more than 100 large and small companies, government agencies, and North Carolina State University units, receives high praises from our survey and interview respondents.

- The North Carolina Electronics and Information Technologies Association is a non-profit organization established to promote and strengthen the electronics, telecommunications, software, Internet, and related service industries in North Carolina through increased public awareness, and to provide a forum to learn, educate, communicate, promote, network, and implement actions. Several interviewees cited the North Carolina Electronics and Information Technologies Association as being very helpful for start-ups, especially in the communications equipment cluster.
- The Triangle J Council of Governments is a voluntary organization of municipal and county governments in North Carolina's Region J (Chatham, Durham, Johnston, Lee, Orange and Wake counties). It is one of 18 regional councils established in 1972 by the General Assembly. The Triangle J Council of Governments currently coordinates a regional water supply monitoring program, a regional household hazardous waste collection program, a critical incident stress management team, an older worker job-training program, a regional ombudsman program to investigate complaints of nursing home patients, and community development internships for graduate students from area universities. The Triangle Transit Authority, the World Trade Center of North Carolina, the Triangle Land Conservancy, and the Greater Triangle Regional Council also originated at the Triangle J Council of Governments.

Exhibit 53: Selected Institutions for Collaboration, Research Triangle Region

Private Sector

- Research Triangle Foundation (RTF)
- Council for Entrepreneurial Development (CED)
- Greater Triangle Regional Council (GTRC)
- Research Triangle Institute (RTI)
- North Carolina Electronics and Information Technology Association (NCEITA)
- Duke University Medical Center (DUMC)
- North Carolina Citizens for Business and Industry (NCCBI)
- Durham, Raleigh, Cary, and Chapel Hill Chambers of Commerce

Joint Private/Public

- North Carolina Biotechnology Center (NCBC)
- Research Triangle Regional Partnership (RTRP)
- Microelectronics Center of North Carolina (MCNC)
- North Carolina State Univ. Centennial Campus
- North Carolina Information Highway (NCIH)
- Wake Education Partnership and Durham Public Education Network

Informal Networks

- IBM Alumni
- Cisco Alumni
- GlaxoSmithKline Alumni
- Univ. of North Carolina-Chapel Hill, North Carolina State Univ., Duke University and North Carolina Community College System Alumni
- North Carolina Governor's Boards and Taskforces

Public Sector

- University of North Carolina Health Care System
- National Institute of Environmental Health Sciences (NIEHS)
- Council of Governments (COG)
- Triangle Transit Authority (TTA)
- Center for Advanced Computing and Communication (CACC)

Source: Interviews, Organizations, Websites

- The Greater Triangle Regional Council was formed in 1993 to identify long-range strategies to improve the quality of life and economic effectiveness of the Research Triangle region. The Council brings together business, academic, government and civic leaders to set strategic, long-term directions, consider ventures needed to achieve success, identify resources needed, and muster the team to implement the ventures. One such project was the Development Choices Project which presented scenarios depicting different ways the region might grow. In 1998, eight principles for improving conservation, development, and mobility in the region were implemented and are currently in use by various regional groups.

For a more comprehensive listing of institutions for collaboration in the Research Triangle, see Exhibit 53 on the previous page.

Institutions for collaboration have been important factors encouraging the development of the Research Triangle's economy. The human assets and basic research needed to grow knowledge-based cluster existed in the Research Triangle by the early 1980s. Yet it was not until the late 1980s, after informal networks had grown, that these types of clusters took off. One measure of the increasing role of informal networks is the steady rise in the region's philanthropy. North Carolina Giving, an encyclopedia of philanthropy in the state, indicates that 36 foundations operate in Durham County, 35 in Orange County, and 88 in Wake County. Those foundations have $8.05 billion in assets.[59]

Attitudes toward Business

Since the 1950s, the Research Triangle's leaders have sought to build a knowledge-based economy where basic research from institutions such as the University of North Carolina-Chapel Hill, Duke University, North Carolina State University, and others would translate into commercial products. Success depended not only on institutions for collaboration like the Research Triangle Institute, but also on the attitudes of scientists and engineers doing basic research. If these individuals were uninterested in working with industry, even the best institutions for collaboration would fail to bring the two groups together.

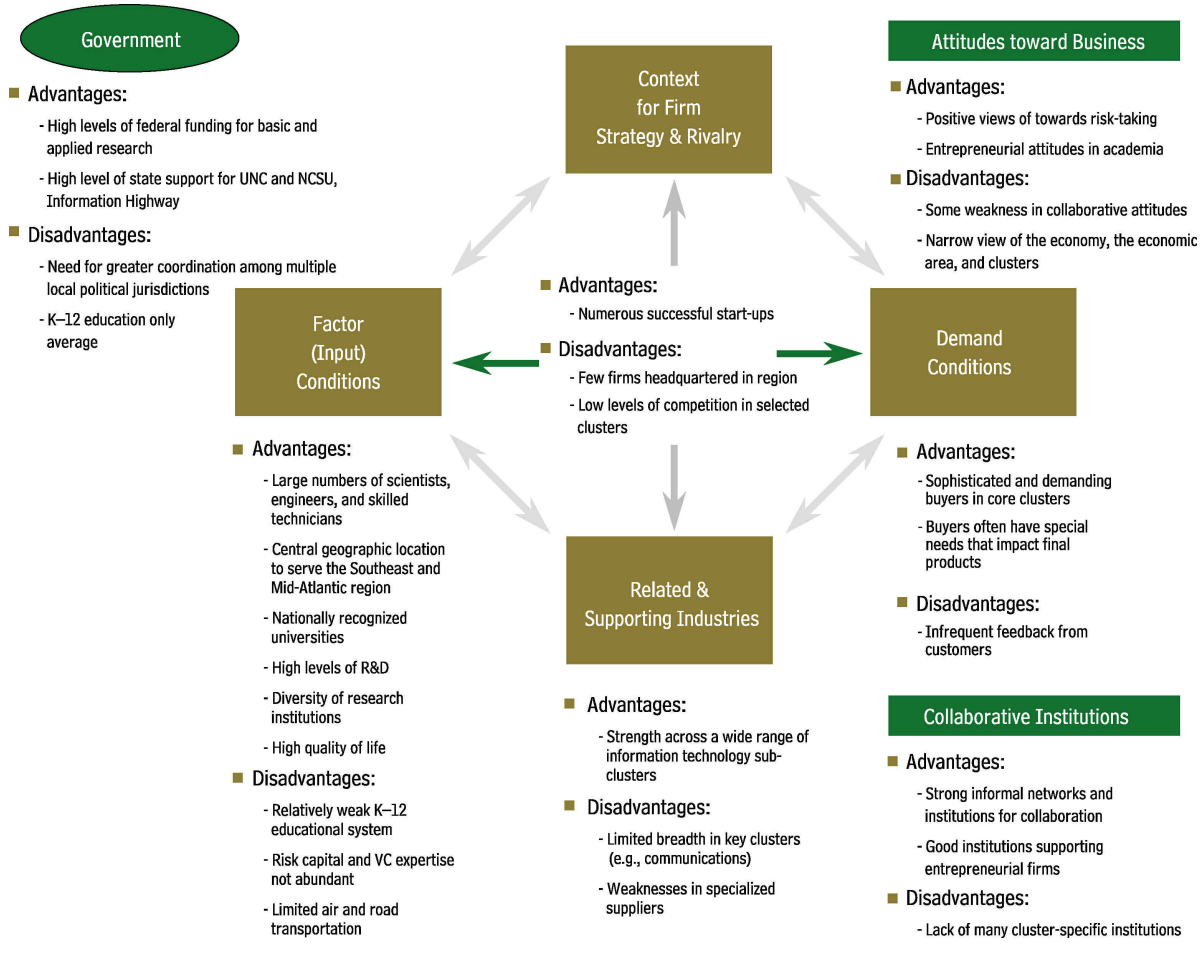
The passage of the Bayh-Dole Act in the early 1980s encouraged universities to take a more aggressive approach to technology transfer. But, it was the transfer of people that really made the difference in the Research Triangle. For example, the list of the Research Triangle Park professionals who joined the area's university faculty is impressive. It includes statistician Ross Ledbetter, who went from the Research Triangle Institute to the University of North Carolina-Chapel Hill, and Duke University historian John Hope Franklin, who was hired after a fellowship at the National Humanities Center. Adjunct professors include three Nobel Prize winners — George Hitchings, Gertrude Elion, and Martin Rodbell.

On the flip side, those who moved from faculty positions to the Research Triangle Park include a group of top GlaxoSmithKline researchers from Duke University Medical School, among them James Niedel, executive director of worldwide research and development; Robert Bell, vice president of United States research; Richard Kent, chief medical officer of GlaxoSmithKline; and Allen Roses, vice president and worldwide director of genetics. Non-GlaxoSmithKline ex-faculty includes Lyman Ripperton, an environmental chemist who went from the University of North Carolina-Chapel Hill to the Research Triangle Institute. That list does not include former university professors — such as SAS Institute CEO Jim Goodnight and Quintiles Transnational CEO Dennis Gillings, who formed their own technology businesses just outside the Research Triangle Park.

In fact, the very beginnings of the Research Triangle Park can be partly attributed to the efforts of academics who pushed for research both within the university systems and within the private sector companies. For example, Bill Little was, at the time of the Research Triangle Park's founding, a chemistry professor at the University of North Carolina-Chapel Hill who became a "traveling salesman" for the park concept. Meeting with executives of the nation's largest chemical companies, Little learned first-hand how hard it was to convince them to relocate to the Research Triangle. But his efforts, and the efforts of others, eventually paid off.

These impressive business-oriented attitudes aside, there are other (less business-friendly) positions that threaten to slow down the region's progress. For example, one educational leader notes, "the State is hampering innovation by not granting an exemption to the universities from the Umstead Act (generally considered to be a bureaucratic barrier). The Umstead Act has a chilling effect on innovation due to the potential costs incurred by professors who start up a business." Currently only the Centennial Campus and a handful of other state institutions are exempt from the Umstead Act. Exhibit 54 below shows the determinants of regional competitiveness for the Research Triangle region.

Exhibit 54: Determinants of Regional Competitiveness, Research Triangle



Source: Clusters of Innovation Initiative Regional Survey™ and Interviews

COMPETITIVENESS OF SELECTED CLUSTERS 4

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 the Research Triangle.

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 pharmaceutical / biotechnology and communications equipment clusters in the Research Triangle. These two clusters are both good performers, and hence offer lessons for other clusters and regions. We also conduct brief case studies of the textiles, chemicals, and plastics clusters. These five clusters are not representative of all clusters in the Research Triangle.

THE PHARMACEUTICAL / BIOTECHNOLOGY CLUSTER

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 5.55% of cluster employment in 1999. Added together, the metro areas of New York and New Jersey would create the largest region. Other important pharmaceutical / biotechnology centers are present in Los Angeles, Chicago, and Washington, DC.

The pharmaceutical / biotechnology cluster in the Research Triangle is a leading national center of R&D. Approximately 65% of biotechnology companies in North Carolina are located in the Research Triangle Park. The cluster has grown rapidly both in terms of employment— adding more than 6,206 jobs as an MSA broad cluster definition (2,531 as an EA narrow cluster definition) —and in terms of patent output— as an MSA it had the 16th fastest growth rate of patent registration out of the 20 largest U.S. clusters (ninth

as an EA). The main features of the cluster's composition are the many large companies like GlaxoSmithKline, BASF, Bayer, and Novo Nordisk Biochem—which tend to focus on several drug development targets—as well as the numerous research institutions such as the Duke University Medical Center, the University of North Carolina-Chapel Hill, and the National Institute of Environmental Health Sciences—which have strong international reputations in bio-science.

Our assessment of the innovative capacity of the Research Triangle cluster shows the vital importance of having quality factor inputs, and in particular human capital, for developing a pharmaceutical / biotechnology cluster. Government and private sector efforts attracted a mass of bioscience 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 the Research Triangle's Pharmaceutical / Biotechnology Cluster

The Research Triangle's pharmaceutical / biotechnology cluster came to life in 1959 when Chemstrand purchased 100 acres from (then) Pinelands Co. (now the Research Triangle Park) and started construction of the first major corporate laboratory in the region.[61] The region got its first biosciences research operation in 1965 when Governor Terry Sanford announced that the United States Department of Health, Education and Welfare (later the National Institute of Environmental Health Sciences) decided to build a $70 million facility in the Park. This important center was presented with 509 acres within the Research Triangle Park in 1965 to serve as a site, producing the first major pharmaceutical / biotechnology anchor tenant for the Park and the region.

The National Institute of Environmental Health Sciences had planned to have its headquarters in Bethesda along with all other National Institutes of Health agencies. But two North Carolina governors were able to convince the federal government to bring the newly created agency to the Research Triangle Park. Governor Terry Sanford, who during the 1960 Democratic convention had seconded John F. Kennedy's presidential nomination when Kennedy badly needed the support of a strong southern political leader was a key player in getting the National Institute of Environmental Health Sciences to the Research Triangle Park. In 1966, the federal government was offered 509 acres of free land for the National Institute of Environmental Health Sciences campus that had been donated by the Research Triangle Foundation. With the help of former Governor Luther Hodges, then Secretary of Commerce, the Research Triangle Park became home to the National Institute of Environmental Health Sciences in 1968.[62]

The National Institute of Environmental Health Sciences spends $94 million annually in North Carolina, and most of that is funneled through the Research Triangle Park. A large part of the National Institute of Environmental Health Sciences' mission involves heading the National Toxicology Program, whose headquarters are on the National Institute of Environmental Health Sciences campus. Established in 1978 and made a permanent activity of the Department of Health and Human Services in 1981, the program accounts for 28% of the National Institute of Environmental Health Sciences' budget.

The next major bioscience research center to locate in the Research Triangle was the United States Environmental Protection Agency, which arrived in the Research Triangle Park just a few months after its creation in 1971. With 1,300 federal employees and an additional 1,000 contract workers on site, the United States Environmental Protection Agency has more than 20 contracts (which include tasks such as research and computer operations for the site) worth up to $600 million with companies and institutions located in the park. The United States Environmental Protection Agency's campus in the Research Triangle Park and its office in Durham represent the largest United States Environmental Protection Agency facility outside of Washington, D.C. and the largest research arm of the agency. The presence of two federal agencies that conduct environmental research has played a large role in attracting businesses in that industry which can support their work.[63]

Another important individual who helped the pharmaceutical / biotechnology cluster gain critical mass was Ned E. Huffman, who became the Research Triangle Foundation's executive vice president, serving in that capacity from 1965 to 1988. During his term of service, the Research Triangle Park experienced tremendous growth, including the recruitment of Burroughs Wellcome in 1971, Glaxo Inc. in 1983, and BASF in 1986.[64] The first foreign investor to put roots in the Research Triangle Park was Burroughs Wellcome, whose company merged and evolved into the pharmaceutical giant GlaxoSmithKline.

In the 1980s, the Duke University Medical Center rose in prominence (see insert on next page) with the creation of the Duke University Comprehensive Cancer Center, which catapulted the Duke University Medical Center into being one of the most important medical centers in the nation. Several interviewees insisted that this designation was instrumental in the Duke University Medical Center becoming a major biomedical center and demonstrates the importance of having a major, federally backed research institution in the region.

In addition to the Duke University Medical Center was the creation of the North Carolina Biotechnology Center in 1984. As was pointed out in numerous interviews with biotechnology executives, the North Carolina Biotechnology Center 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 local universities. It has awarded $42 million in grants since its inception, and in just the past few years raised $30 million from state and private sources for the Bioscience Investment Fund, envisioned as a source of venture capital for creating and growing about 20 biotechnology firms over the next five to ten years. Some companies North Carolina Biotechnology Center has assisted include Sphinx Pharmaceutical, Embrex, and Cardiovascular Diagnostics. The North Carolina Biotechnology Center has also helped recruit Biogen and Covance, attract top faculty to the state's universities, and provide more than 500 grants to 20 North Carolina universities for institutional development and innovative research.

Duke University Medical Center. The Duke University Medical Center is one of the most famous medical centers in the eastern United States. It is a nucleus of biomedical research in North Carolina and is perhaps one of the most important reasons why the Research Triangle has been able to develop its pharmaceutical / biotechnology cluster to the extent it has.

The Duke University Medical Center has a very good reputation in basic and clinical biomedical research; cancer and urology are especially strong research fields. The Duke University Medical Center includes the School of Medicine and College of Allied Health and School of Nursing, Duke University Hospital, Durham Regional Hospital, Duke University Comprehensive Cancer Center, and the Center for Human Genetics. The medical departments have been divided into basic and clinical sciences offering doctoral research programs. There is a broad range of basic science research including biochemistry, cell biology, genetics, immunology, microbiology, neurobiology, and pharmacology and cancer biology, carried out in 38 laboratories.

The Duke University Comprehensive Cancer Center has consistently retained its comprehensive status conferred by the National Cancer Institute and based on rigorous guidelines. Some of the established research programs are in cancer immunobiology, cancer prevention, detection and control, cell regulation and transmembrane signaling, cellular and structural biology, experimental therapeutics, molecular oncology, and cancer genetics.

Another part of the Duke University Medical Center is the Comprehensive Center for Inflammatory Disorders. Established in 1999, the Center is one of six national Comprehensive Oral Health Research Centers of Discovery created by the National Institute of Dental and Craniofacial Research to improve the oral health of Americans.

The University of North Carolina-Chapel Hill also has leading medical institutions. The Lineberger Comprehensive Cancer Center is one of the biomedical centers in the University of North Carolina-Chapel Hill School of Medicine and is part of the National Cancer Institute's nationwide Cancer Center Program. The main training programs are in the fields of cancer cell biology and virology.

The University of North Carolina-Chapel Hill School of Medicine is also well regarded and is active in biomedical engineering. The principal areas of research within the Department of Biomedical Engineering are in medical imaging, biomedical computer communications, medical informatics, neuroscience engineering, bioelectronics and sensors, physiological system modeling, biomaterials, and real-time computer systems. The University of North Carolina-Chapel Hill faculty in the departments of cell biology and anatomy, cell and molecular physiology, and microbiology and immunology conducts research in 37 individual laboratories.

Since 1990, the Research Triangle has achieved a respected role in the bioinformatics industry because companies such as Nortel Networks, SAS Institute, IBM, and Cisco Systems, all information giants, are nestled together with companies such as GlaxoSmithKline, BASF, Novartis, Bayer, Aventis, and DuPont, all giants in biotechnology, and surrounded by academic research. In addition, the Research Triangle region has another bioinformatics edge with the presence of large specialized companies like Quintiles and PPD, Inc.[65]

In 1999, Bayer Corporation relocated the worldwide headquarters of its Biological Products Business Unit to the Research Triangle Park from West Haven, Connecticut. Bayer Biological Products focuses on discovering, manufacturing and marketing plasma-derived therapies and their genetically engineered or gene therapy replacements. Biological Products employs 2,200 people in the United States and is a business unit within Bayer's global Pharmaceutical Business Group, which is a part of Bayer's Worldwide Group, a $32 billion chemical and pharmaceutical company. [66]

Case Study of GlaxoSmithKline

In the late 1960s, Burroughs Wellcome had difficulty finding affordable laboratory space in its former home of Westchester County, New York, and so relocated to the Research Triangle Park. This major move confirmed for the world that the Park was a strategic relocation—not only as a Sunbelt work site for expansions but also as a great place for top scientists to call home.

As the Burroughs Wellcome move heralded the Research Triangle Park's emergence as an international crossroads, it bolstered the medical research portion of the development portfolio as well. Burrough's move precipitated other companies to follow suit, including Becton-Dickinson Co., known to consumers for its thermometers and to the science world for its artificial kidney technology, which opened a research center in the Research Triangle Park.

Both Glaxo and Burroughs Wellcome independently chose the Research Triangle Park for their United States headquarters. That certainly helped ease the transition when the two companies merged. But it also shows that both companies recognized the advantages offered by the area, including North Carolina State University's agricultural program as well as the availability of research talent in general.[67] Glaxo originally had its United States headquarters in Tampa, Florida, with manufacturing in St. Louis. Glaxo eventually moved both of these areas of the company, as well as research operations, to the Research Triangle.

The success of Burroughs Wellcome was important to the Research Triangle's developing pharmaceutical / biotechnology 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 mergers provided significant capital to employees eager to start new ventures.

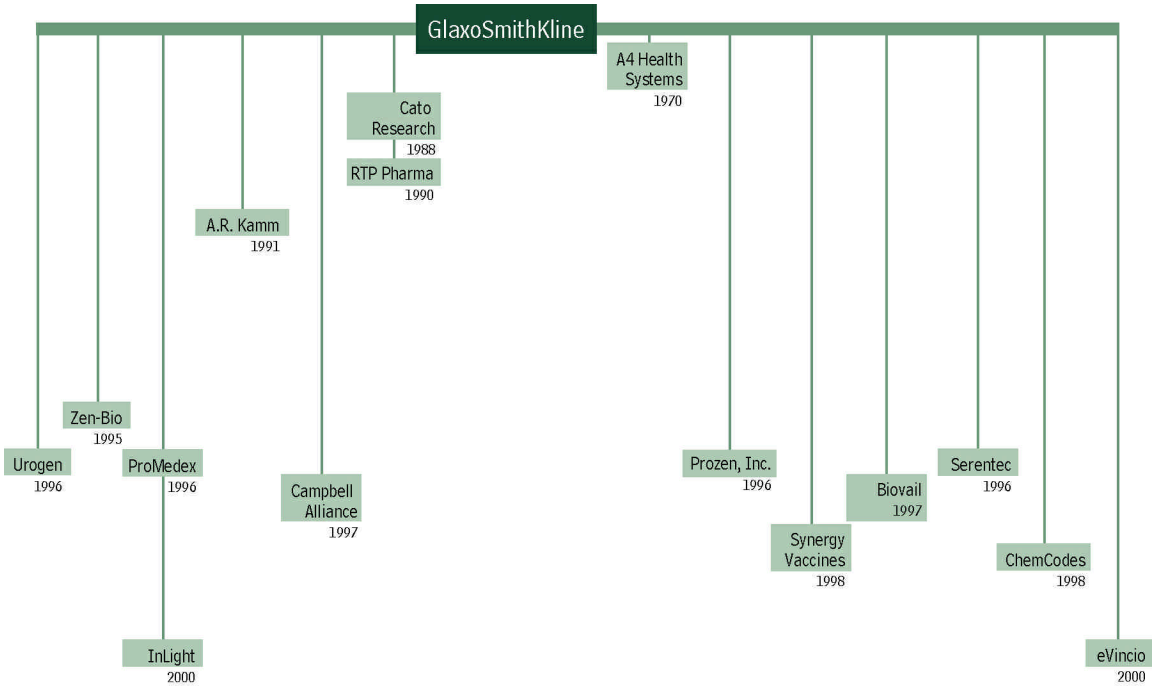
The relationship between the universities and the Research Triangle Park companies has done more than just attract good people. It has also improved the universities' research infrastructure — especially in sciences. When Glaxo decided to build its large research facility in the Research Triangle Park, they needed a place to house researchers before the building could be finished. In 1986 Glaxo paid for $3.5 million in renovations to the University of North Carolina-Chapel Hill's main chemistry building and to build a new $3 million medical building on campus. When the company finished using the space, it donated the facilities back to the university.

Anchor firms play a large role in building clusters by performing several functions. First, they act as magnets for other major companies—both rival and allied companies—that will move to a region simply to be near the anchor company. Second, anchor companies tend to organize other companies in a cluster for collective action, such as lobbying government for infrastructure improvements, or collaborating with universities to build specialized research and training facilities. Third, anchor companies, and in particular major companies with headquarters in a region, tend to be more involved in supporting community projects that improve the local quality of life. Finally, a particularly important function of anchor companies is that they produce numerous spinout companies, which strengthen key elements of the cluster.

The anchor firm is generally the buyer of the goods and services of its spinouts, and local demand in the cluster is improved. By producing numerous spinouts, the anchor increases the presence of local related and supporting industries. In some cases, spinouts directly compete with the parent anchor company, and this results in a more vibrant context for firm strategy and rivalry. Finally, due to the personal "alumni" relationships among individuals in the anchor and the spinouts, a strong web of informal networks tends to form, and cluster collaboration improves.

Anchored by GlaxoSmithKline, the Research Triangle has become a world-leading center in pharmaceutical / biotechnology, with numerous start-up firms having been spun out from GlaxoSmithKline's local operations. Exhibit 55 below, demonstrates how many successful companies have spun out of GlaxoSmithKline, especially after mergers, acquisitions, and reorganizations result in lay-offs.

Exhibit 55: Anchor Companies, Development of Research Triangle Pharmaceutical / Biotechnology Cluster



Source: NCBC, Triangle Business Journal and Dr. W.F. Little

Sometime in the 1990s, the Research Triangle pharmaceutical / biotechnology cluster reached a critical mass such that growth no longer depended on outside sources. New research centers, like Biogen's cell culture facility, had been established. 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 in the Research Triangle Park encouraged collaboration and growth. For example, Bayer set up part of its research facilities in the Research Triangle Park so it could be close to Duke University Medical Center to conduct clinical trials on some of its drug candidates.[68]

Currently, the Research Triangle's pharmaceutical / biotechnology cluster is split along two main lines of activities: 70% of the organizations in the area are involved in pharmaceutical, including nine of the ten largest, fully integrated pharmaceutical companies in the country, more than 54% contract research organizations, and 40 other large pharmaceuticals involved in such highly specialized disciplines as bio-informatics, nanotechnology-based photonics and genomics; while 30% of the organizations in the cluster are involved in agriculture or environmental-related biotechnology activities, including improved rowcrops, value-added crops, forestry products, toxicological products, and clinical research. Some additional areas of focus for the cluster have been in the areas of bio-informatics.

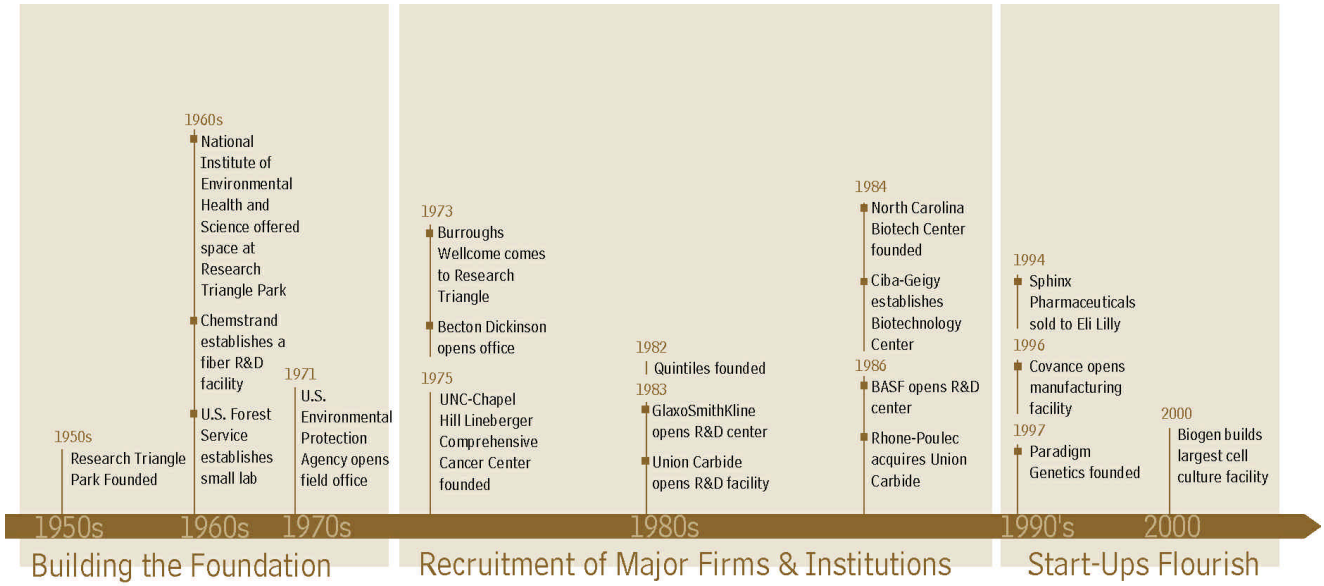
Exhibits 56a and 56b summarize the Research Triangle's pharmaceutical / biotechnology cluster timelines.

Exhibit 56a: Pharmaceutical / Biotechnology Cluster Timeline, Research Triangle Region

Historical Obstacles	Important Enablers	Key Events
■ Little historical tradition as a leading region in bio-sciences	■ Good quality of life and geographic location	■ Formation of RTI and NCBC (and its ambitious research agenda)
■ Lack of local venture capital	■ Success in attracting and creating world-class academic research centers	■ Success of GlaxoSmithKline
■ Lack of local specialized support services	■ Government R&D funding	■ Rise in Duke University Medical Center's prominence
■ Lack of image as a cosmopolitan business center	■ Formation of institutions for collaboration	■ UNC-Chapel Hill Lineberger Cancer Center
	■ Culture of cooperation and civic pride	■ Establishment of Quintiles
		■ Sale of Sphinx Pharmaceuticals to Eli Lily

Source: Clusters of Innovation Initiative Regional Survey™ and In-person Interviews

Exhibit 56b: Pharmaceutical / Biotechnology Cluster Timeline, Research Triangle Region



Source: Clusters of Innovation Initiative Regional Survey™ and In-person Interviews

RECENT ECONOMIC PERFORMANCE

The Clusters of Innovation Initiative assessed the Research Triangle's regional economy using the Metropolitan Statistical Area (MSA) broad cluster definition, and, in some cases where it is warranted, the Economic Area (EA) narrow cluster definition. Broad and narrow cluster definitions of the MSA and EA can be explained as follows. Clusters are made up of industries. Some industries are core to a cluster. For example, x-ray devices are core to the medical devices cluster. But these same industries are also of secondary importance to other clusters; x-ray machines are also part of, but not core to, the analytical instruments cluster. Thus, a narrow cluster classification only incorporates core industries, while a broad cluster classification includes industries that are both core and of secondary importance. MSA broad cluster definition can be thought of as being similar to the conventional wisdom in a region for a particular industry, while an EA narrow cluster definition is but another way to provide important and valuable insight.

Employment. In 1999, the Research Triangle MSA (broad cluster definition) had 14,554 pharmaceutical / biotechnology workers, making it the nation's 23rd largest MSA with 1.08% of the nation's pharmaceutical / biotechnology employment.[69] As measured by location quotient, the Research Triangle cluster was the eight most concentrated MSA of the 30 largest clusters in the United States.[70] From 1990 to 1999, the Research Triangle's pharmaceutical / biotechnology cluster had an annual growth rate of 6.4%, the fastest among the 20 largest MSAs. (See Exhibit 57 on the following page.)

Exhibit 57: Pharmaceutical / Biotechnology Cluster, Leading MSAs by Total Employment, Broad Cluster Definition

Metropolitan Area	1999 Total Employment	Employment CAGR 1990–1999	Establishments CAGR 1990–1999	1999 Average Wages	Patents per 1000 Employees 1998	CAGR of Patents 1990–1998
Boston-Worcester-Lawrence-Lowell-Brocktn, MA-NH	74,721	1.7	4.7	$63,496	9.0	10.9
Chicago, IL	65,329	-0.7	1.8	$52,196	4.0	5.6
Los Angeles-Long Beach, CA	47,143	-1.6	2.2	$46,359	5.0	10.5
Newark, NJ	43,693	2.2	1.6	$73,415	3.8	0.5
New York, NY	43,245	2.1	1.4	$56,192	6.6	6.1
Washington, DC-MD-VA-WV	39,973	5.4	4.3	$61,712	7.0	7.4
Philadelphia, PA-NJ	37,374	-1.9	2.7	$56,547	10.2	11.0
San Diego, CA	34,244	5.4	7.8	$60,118	11.5	14.9
Minneapolis-St. Paul, MN-WI	33,654	5.3	4.9	$41,523	6.1	3.7
San Jose, CA	33,006	5.3	6.4	$88,940	11.7	8.7
Middlesex-Somerset-Hunterdon, NJ	30,520	0.5	4.9	$61,468	5.4	3.4
Nassau-Suffolk, NY	27,432	-1.0	1.9	$38,970	3.3	9.1
Orange County, CA	26,237	1.4	4.3	$48,099	5.9	7.4
New Haven-Bridgprt-Stamfrd-Danbry-Wtrbry, CT	21,779	0.4	2.6	$63,865	6.4	5.8
Oakland, CA	19,651	0.8	5.8	$57,719	11.7	10.5
Atlanta, GA	18,795	2.5	5.5	$58,086	5.1	9.7
Baltimore, MD	18,579	1.4	6.1	$59,406	6.4	14.1
San Francisco, CA	18,173	4.1	4.2	$80,100	21.3	14.1
Seattle-Bellevue-Everett, WA	16,647	3.0	4.8	$55,351	9.9	8.6
Houston, TX	16,402	4.2	3.0	$49,174	8.9	0.6
Raleigh-Durham-Chapel Hill, NC	14,554	6.4	8.8	$55,759	9.7	9.9

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

In 1999, the Research Triangle EA (narrow cluster definition) had 8,501 pharmaceutical / biotechnology workers, making it the nation's sixth largest EA with 3.3% of the nation's pharmaceutical / biotechnology employment).[71] As measured by location quotient, the Research Triangle cluster was the second most concentrated EA of the 20 largest clusters in the United States.[72] From 1990 to 1999, the Research Triangle's pharmaceutical / biotechnology cluster had an annual growth rate of 4.0% annual growth rate and 11th fastest among the 20 largest EAs. (See Exhibit 58 on the following page).

Exhibit 58: Pharmaceutical / Biotechnology Cluster, Leading EAs by Total Employment, Narrow Cluster Definition

Economic Area	1999 Total Employment	Employment CAGR 1990–1999	Establishments CAGR 1990–1999	1999 Average Wages	Patents per 1000 Employees 1998	CAGR of Patents 1990–1998
New York-New Jersey-Long Island, NY-NJ-CT-PA-MA-VT	75,918	-0.1	0.5	$59,887	7.1	6.3
Los Angeles-Riverside-Orange County, CA-AZ	20,142	2.4	3.1	$37,272	7.4	11.6
Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD	11,491	-5.7	3.0	$38,718	18.6	14.8
Grand Rapids-Muskegon-Holland, MI	9,524	4.3	1.1	N/A	2.8	5.5
Indianapolis, IN-IL	9,496	-0.9	4.0	N/A	9.5	11.9
Raleigh-Durham-Chapel Hill, NC	8,501	4.0	7.0	$49,331	7.3	12.4
Chicago-Gary-Kenosha, IL-IN-WI	7,961	-12.4	1.8	$37,533	11.6	19.2
Boston-Worcester-Lawrence-Lowell-Brockton, MA-NH-RI-VT	7,837	10.2	4.2	$53,348	43.4	6.8
Dallas-Fort Worth, TX-AR-OK	7,673	7.9	1.4	$34,595	4.3	0.3
San Francisco-Oakland-San Jose, CA	7,604	4.2	5.2	$47,737	50.5	10.9
St. Louis, MO-IL	5,640	7.1	3.2	$43,384	11.1	5.8
Washington-Baltimore, DC-MD-VA-WV-PA	5,052	4.1	6.7	N/A	37.0	14.7
Syracuse, NY-PA	3,808	4.9	1.8	N/A	5.6	7.1
Cleveland-Akron, OH-PA	3,731	5.9	2.3	$35,396	6.1	-1.3
Atlanta, GA-AL-NC	3,590	3.6	3.5	$31,187	13.7	11.1
Cincinnati-Hamilton, OH-KY-IN	3,475	-5.3	2.2	$47,209	17.4	13.1
Phoenix-Mesa, AZ-NM	3,057	1.4	7.4	N/A	1.7	-0.1
Minneapolis-St. Paul, MN-WI-IA	3,050	-0.4	6.0	$38,704	15.5	8.5
Tampa-St. Petersburg-Clearwater, FL	3,009	18.1	8.8	$33,286	3.4	-3.7
Salt Lake City-Ogden, UT-ID	2,740	16.0	13.3	N/A	8.6	0.9

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

Average Wages. In 1999, the average wage in the Research Triangle pharmaceutical / biotechnology cluster MSA was $55,759 (14th highest among the largest 20 regions), roughly 8.83% above the national average for the cluster. Between 1990 and 1999, the Research Triangle's MSA average wage increased at an average annual rate of 6.8% (eight highest growth rate among the 20 largest regions).

In 1999, the average wage in the Research Triangle pharmaceutical / biotechnology cluster EA was $49,331 (third highest among the largest 20 regions). Between 1990 and 1999, the Research Triangle's EA average wage CAGR is not available.

Patents Registration. In 1998, the Research Triangle MSA pharmaceutical / biotechnology cluster (broad cluster definition) registered 122 patents (18th highest patent total among the 20 largest regions), or 9.7 patents per 1,000 employees (seventh highest among the 20 largest MSAs in the nation). Over the 1990-1998 period, patenting grew at an average annual rate of 9.9%, the eight fastest among the 20 largest MSA clusters, with the fastest being San Diego at 14.9%.

The pharmaceutical / biotechnology cluster in the Research Triangle MSA (broad cluster definition) does well in terms of cited patents as well. It had 261 cited patents per 1000 employees, which was roughly 79% above the national average for the cluster. Data limitations preclude measuring growth in cited patents.

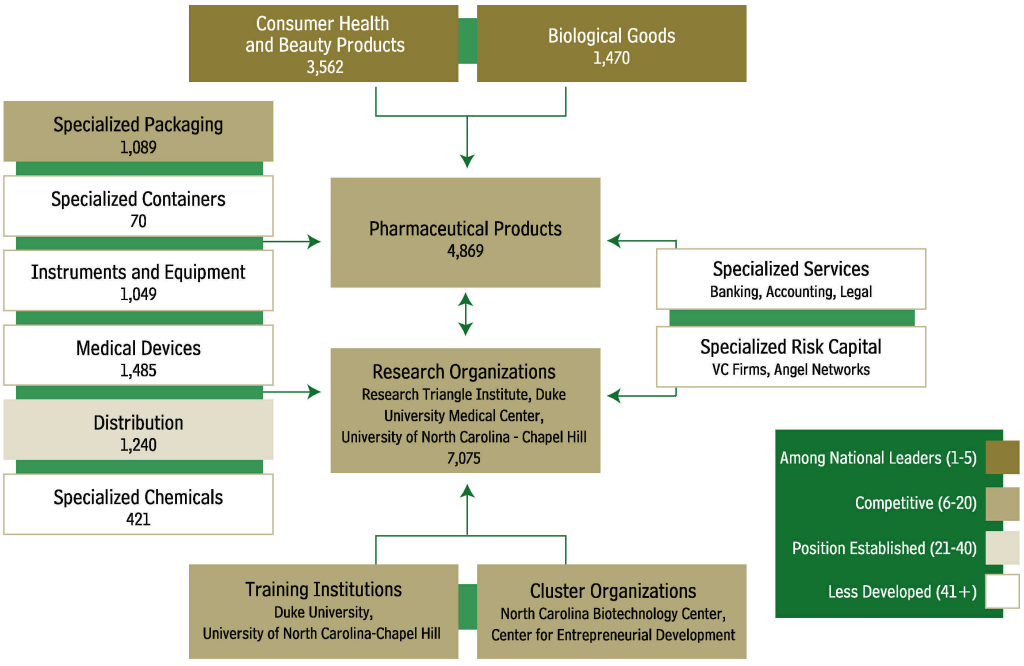
In 1998, the Research Triangle EA pharmaceutical / biotechnology cluster (narrow cluster definition) registered 61 patents (ninth highest patent total among the 20 largest regions), or 7.3 patents per 1,000 employees (13th highest among the 20 largest regions in the nation). Over the 1990-1998 period, patenting per 1,000 employees grew at an average annual rate of 12.4%, the 5th fastest among the 20 largest EA clusters, with the fastest being Chicago-Gary-Kenosha, Illinois-Indiana-Wisconsin at 19.2%.

VC Funding and IPOs According to PriceWaterhouseCooper's Money Tree, the Research Triangle's biotechnology firms received $208 million in VC funding from 1995 to 1999. This was 4.9% of the national total, almost five times the U.S. average on a per biotechnology worker basis.

DESCRIPTION OF THE REGIONAL PHARMACEUTICAL / BIOTECHNOLOGY CLUSTER

Exhibit 59 below depicts the competitive position of the Research Triangle EA 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 Clusters Mapping Project.

Exhibit 59: Competitive Position, Research Triangle EA Pharmaceutical / Biotechnology Cluster



Note: Employment numbers are given inside boxes were available
Source: Regional Survey Data, Cluster Mapping Project, institute for Strategy and Competitiveness, Harvard Business School and In-person Interviews

The Research Triangle's Competitive Position. The Research Triangle pharmaceutical / biotechnology cluster is focused on research, having one of the strongest critical masses of R&D and clinical testing institutions in the nation. The cluster is competitive in the specialized packaging, pharmaceutical products, research organizations, training institutions, and cluster organizations subclusters. At an industry level, the region has a heavy concentration of employment in agricultural bioscience, bio manufacturing, contract research organizations, and bioinformatics and combinational chemistry. The cluster's weaknesses lie in the following subclusters: specialized containers, instruments and equipment, medical devices, specialized chemicals, specialized services, and specialized risk capital.

More specifically, the cluster has many specialized firms in such areas as agricultural bioscience (Paradigm Genetics and Embrex), bio manufacturing (Biogen and Covance), contract research organizations (Quintiles and PPD) and bioinformatics and combinational chemistry (Paradigm and Novalon Pharmaceutical Corp.). Bioinformatics in particular is a marriage between the Research Triangle's pool of information technology and software talent with biotechnology.

Paradigm, founded in 1997 by four scientists who formerly worked at Novartis AG's crop-protection unit in the Research Triangle Park, combines computer models with an understanding of how genes work to develop genetically altered seeds and create new pesticides and herbicides designed to improve crop yields and reduce the amount of chemical sprayed on fields. Paradigm is one of the first companies to use this research approach in the agricultural field.

Covance, established in 1995 and headquartered in Princeton, N. J., has played off a traditional strength of the Research Triangle Park-region—clinical trial work. The company produces drugs in small batches for clinical trials and it manages trials. Still, there are no big bioinformatics players in the Research Triangle, and there are still some hurdles the local biotechnology industry needs to overcome.

Two years ago, the North Carolina Biosciences Organization, a trade group, addressed the problems in a report that coincided with the expiration of a state tax credit for angel and seed investors. Since then, the tax credit has been extended and available venture capital in the Research Triangle—and companies offering it—has more than doubled.[73] While some of these small biotechnology start-ups grow, the majority of the cluster's employment is housed in the larger pharmaceutical companies. Leading international firms like GlaxoSmithKline— whose U.S. headquarters is in the Research Triangle— BASF, Novartis, Bayer and Aventis have set up major research and development operations in the region.

Exhibit 60 on the following page, shows the competitive position of sub-clusters and industries in pharmaceutical / biotechnology in the Research Triangle. Commercial physical research organizations are the greatest area of strength, employing more than 5,110 people, which constitutes more than 2.2 percent of the country's employment sub-cluster in commercial physical research organizations.[74] Pharmaceutical products is 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 also impressive. In particular, biological products, medical devices, and noncommercial research organizations also have healthy shares of national employment (though generally not growing as fast).

Exhibit 60: Pharmaceutical / Biotechnology Sub-Clusters, Research Triangle MSA, Broad Cluster Definition, 1999

Sub-Cluster	Narrow or Broad	SIC	Label	National Percentage Share 1999	Total Employment 1999	Employment CAGR 1990–1999
Biotechnology and Pharmaceutical Cluster				1.1	14,554	6.4
Pharmaceutical Products*	Narrow	2833	Medicinals and botanicals	2.4	685	16.4
	Narrow	2834	Pharmaceutical preparations	1.3	1,671	6.8
Containers*	Narrow	3085	Plastics bottles	0.2	60	
Consumer Goods*	Narrow	2844	Toilet preparations	0.1	60	
Distribution	Broad	5120	Drugs, proprietaries, and sundries	0.6	1,210	13.7
Biological Chemical	Broad	2836	Biological products except diagnostic	5.0	1,095	4.3
Specialty Chemicals	Broad	2843	Surface active agents	0.1	10	
	Broad	2865	Cyclic crudes and intermediates	0.0	0	
	Broad	2899	Chemical preparations, n.e.c.	1.1	401	33.4
Packaging	Broad	3221	Glass containers	0.0	0	
	Broad	3466	Crowns and closures	5.7	235	
	Broad	3497	Metal foil and leaf	0.1	18	-100.0
Laboratory Instruments and Process Equipment	Broad	3821	Laboratory apparatus and furniture	0.5	89	27.5
	Broad	3823	Instruments for process measurement	0.1	60	13.0
	Broad	3826	Analytical instruments	0.4	129	5.5
	Broad	3827	Optical instruments and lenses	0.1	10	
	Broad	3829	Measuring and controlling devices, n.e.c.	2.1	750	3.5
Medical Devices	Broad	2835	Diagnostic substances	1.9	781	
	Broad	3841	Surgical and medical instruments	0.2	244	18.1
	Broad	3843	Dental equipment and supplies	0.0	0	-14.4
	Broad	3844	X-ray apparatus and tubes	0.1	10	-100.0
	Broad	3845	Electromedical equipment	0.0	9	
	Broad	3850	Ophthalmic goods	0.0	0	-39.2
Research Organizations	Broad	6794	Patent owners and lessors	0.9	227	31.0
	Broad	8731	Commercial physical research	2.2	5,115	9.1
	Broad	8733	Noncommercial research organizations	2.0	1,683	5.1

* Denotes a Unique Industry; Blue shading indicates industry with a higher than expected concentration (i.e., > .57% of the nation's employment)
Source: Cluster Mapping Project, institute for Strategy and Competitiveness, Harvard Business School

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 Educational Institutions and Talent Pool. The University of North Carolina-Chapel Hill, North Carolina State University, Duke 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. Interviewees reported satisfaction with local training and talent as far as quality, but not quantity. Eighty-five percent of biotechnology survey respondents in the Research Triangle region indicated that advanced educational programs (e.g., vocational schools, colleges and/or universities) provide their businesses with high quality employees, compared to 75% across all regions.

For example, Biogen started a program with the help of the North Carolina Biotechnology Center at Wake Community College to train employees for one month (paid partly by Biogen) using nine modules and getting people from non-traditional industries; like those coming out of tobacco and textile industries. A sort of intensive boot camp where one can then complete an associate degree while working at Biogen, these North Carolina Biotechnology Center programs point to useful mechanisms for cooperation. These approval ratings are somewhat higher than average for all regions surveyed, with 55.0% of all biotechnology executives stating that associations and organizations that represent their cluster exist and effectively promote the interests of the cluster, compared to a 43.7% average of other regions studied.

As one economic development official noted, "Community colleges are very strong in the region and they tend to focus on tech training, which is unusual since many community colleges focus on transitioning students from high school to four-year colleges." [75] This comment contrasts with the availability of local talent, as indicated by one industry executive, "Entry level managers are lacking, but the hardest thing is to bring Senior VPs of Business Development from the outside. It is hard to recruit them because, in general, laid off employees in the area still don't have enough local firms to jump into. Only a couple of companies are capable of receiving them, versus many more in say, Boston or California."[76]

Specialized Research Centers. Specialized bioscience research centers are a key strength of the cluster. There are six major research institutes in the Research Triangle (see Exhibit 61 below). Ninety percent of survey respondents stated that specialized facilities for research are readily available to their firm, and 60% reported that these institutions frequently transfer knowledge. This compares to 76% percent and 53% respectively across all other regions. Duke University ranks among the top centers in peer-reviewed grants and contracts, with the center receiving large portions of its funding from the National Cancer Institute Core Support Grant — nearly $20 million is expected over a five-year period. The University of North Carolina-Chapel Hill is ranked 13th nationally in cancer research funding to universities, with about $20 million received annually. The economic impact of each medical center is important to the Triangle. Both are their respective county's top employer. Exhibit 61 lists the major biomedical research institutes in the region.

Exhibit 61: Major Biomedical Research Institutes, Research Triangle Region

Institution (Year Founded)	Focus
Research Triangle Institute (1958)	Basic biomedical research (multiple areas)
National Institute of Environmental Health Sciences (1965)	Basic environmental disease research
Duke Clinical Research Institute (1969)	Basic cardiology and infectious diseases research
Duke Comprehensive Cancer Center (1971)	Basic research in cancer
UNC Lineberger Comprehensive Cancer Center (1975)	Basic research in cancer
UNC Comprehensive Center for Inflammatory Disorders (1999)	Basic research on inflammatory disorders

Source: Clusters of Innovation Initiative Interviews, websites of organizations

Anecdotal evidence suggests that the universities have been successful in spurring innovation. For example, North Carolina State University helped form Biolex, a plant biotechnology company using duckweed to synthesize proteins. Another example is Zymotech, a virtual company developing an enzyme system that breaks down the components that cause pollution. Other recent start-ups at North Carolina State University include 3Tex, which was spun out of the College of Textiles, and Lipsinc, which started as the result of research being done in computer technology.[77] North Carolina State University currently gets good marks in technology transfer surveys—the Association of University Technology Managers recently ranked them number 17 among 132 universities surveyed in such technology transfer metrics as amount of license income ($7,761,000), amount of research expenditures ($413,369,000), license income as a percentage of research expenditures (1.9%), and number of licenses and options yielding income (60).[78]

The Office of Technology Development at the University of North Carolina-Chapel Hill has also been successful. That office has helped with Triangle start-ups such as Inspire Pharmaceutical Inc.; Quintiles, Icogen; Sun Technologies Group; Triangle Laboratories Inc.; MiCell, a company developing environmentally safe dry cleaning products; Xanthon Inc., a drug discovery company; and AlphaVax, which is developing vaccines from alpha viruses. The University of North Carolina-Chapel Hill faculty started all these companies.[79] Duke University's efforts have been equally noteworthy. Duke University has spun off 14 companies, including Trimeris Inc. and Volumetric Imaging Inc., and earns $1.5 million a year from licensing fees. Its total revenues from licensing fees, royalties, stock dividends, and collaborative research funding are about $77 million a year.[80]

While they have created their own technology transfer offices and get equity in the new companies, the universities still own the technology, although they do allow joint patents. Professors who create a product, process, or technology may get a leave of absence. There has also been a trend toward decentralizing the patenting process. For example, the Triangle Universities Licensing Consortium was established by the three universities in 1987 and was responsible for licensing patented technologies owned by the universities. But as each of the universities developed the expertise to deal with the companies in the park, the Triangle Universities Licensing Consortium's role came into question. In September 1995, the Triangle Universities Licensing Consortium was dissolved. Each of the three Triangle universities now deals directly with companies in order to bring to market new technologies or inventions.

Context for Firm Strategy and Rivalry. The Research Triangle pharmaceutical / biotechnology cluster exhibits relatively little competitive rivalry, high rate of new firm formation, and norms that reward risk-taking. Forty-two percent of survey respondents described competition as "intense," and 42% said there were a large number of local competitors. Both rates were below average across all the regions we surveyed. From 1990 to 1999, 163 new establishments (including new firms and new locations of existing firms) were created in the Research Triangle, with a CAGR from 1990 to 1999 of 8.8% in the MSA (broad cluster definition). In the Research Triangle EA (narrow cluster definition), 24 new establishments were created, with a 1990-1999 CAGR of 7.0%.

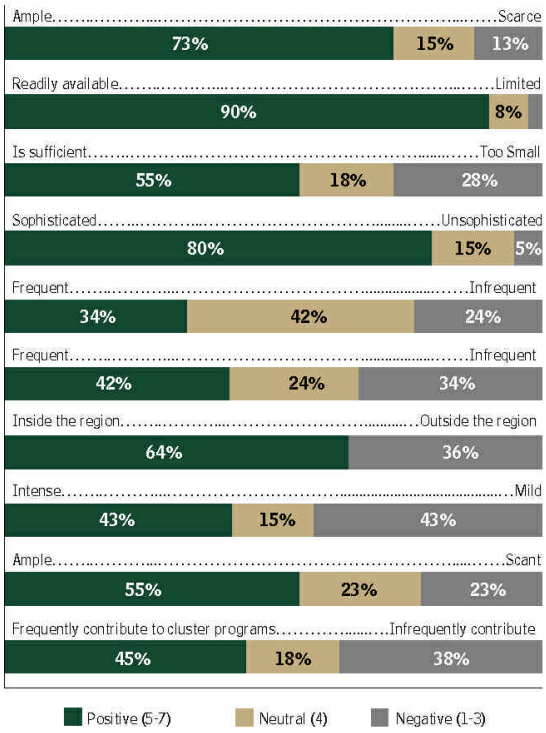
Sophistication of Regional Demand. The Research Triangle pharmaceutical / biotechnology executives expressed mixed views about the level and sophistication of interaction with their local customer base. Nearly 80% of respondents reported that their regional customers were sophisticated and demanding, but they did not feel that this demand provided them with a competitive advantage. Most respondents were neutral or slightly positive (42.1% and 34.2% for each) about the frequency with which customer feedback led to product improvements, and a comparable number wanted more frequent feedback. These numbers are lower when compared to survey respondents across all regions. For example 62% of respondents across all regions reported that their regional customers were sophisticated and demanding, while 49% indicated that they received frequent feedback from regional customers that led to product improvements.[81]

Related and Supporting Industries. There are a number of firms in the Research Triangle that provide lab and testing equipment, and conduct drug testing and small contract manufacturing of trial drugs. Most survey respondents (69.2%) stated that these firms provided high quality goods and services. Sixty-four percent reported that specialized suppliers were frequently available in the region, and 35.9% said they frequently had to go outside the region to source materials, components, and services. Forty-two percent stated that specialized suppliers frequently helped them in the innovation process.[82] Each of these ratings was more positive than the average across all regions surveyed. As an executive at a large pharmaceutical company put it, "There is a lot of contract work that goes on. We do about 35%-45% of our research by contract and IBM has a similar number. This encourages people to start their own companies to get this business."[83]

The Research Triangle 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.

Government. Government actions have had a positive impact on the cluster through federal R&D funding, state founding and funding of the North Carolina Biotechnology Center, and local government's zoning of the Research Triangle Park. Lack of local action on improving air transport facilities and K-12 schools will likely have a significant and negative impact on the cluster. Fifty-five percent of the region's survey respondents indicated that state and local government support for investment in R&D (e.g., funding business incubators, creating consortia) was ample, compared to 35% for survey respondents across all regions. Sixty-six percent of the Research Triangle biotechnology respondents indicated that the government's overall responsiveness and ability to work with the needs of business were high, compared to 39% across all regions. (See Exhibit 62 below.) While these numbers indicate good government involvement in the cluster, several executives cited the need for greater cooperation among the different government jurisdictions, including "the need for one chamber of commerce."[84] One industry executive told the story of their expansion within the Research Triangle Park and how they "needed to get permission from 8 jurisdictions to be able to grow. It took one year to get the approval completed; to the point that even the Governor had to help us pass the changes in the legislature."[85]

Exhibit 62: Select Survey Results, Pharmaceutical / Biotechnology Cluster, Research Triangle



Factors Inputs

- Qualified scientists and engineers in your region are . . .
- Specialized facilities for research are . . .
- The available pool of skilled workers in your region is . . .

Demand Conditions

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

Related and Supporting Industries

- Regional specialized suppliers assist your firm with new product and process development . . .
- Specialized suppliers of your business' materials, components, machinery, and services are mostly available. . .

Rivalry

- Regional competition in your industry is . . .

Government

- State and local government support for investment in R&D (e.g., funding business incubators, creating consortia) is . . .

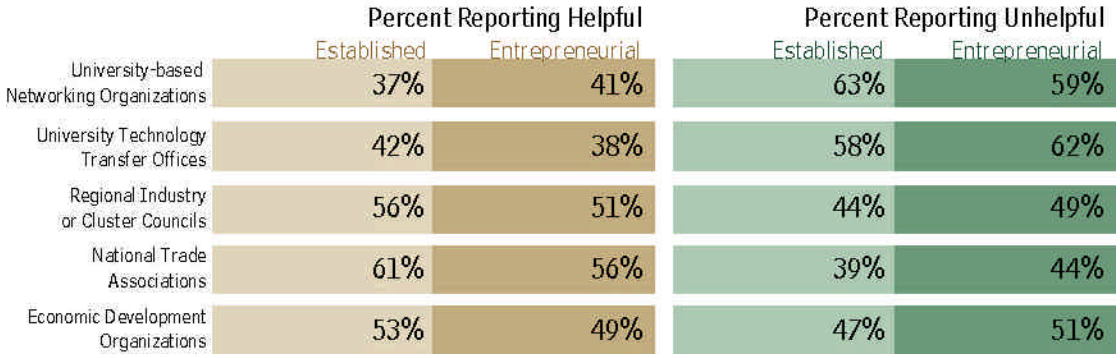
Attitudes

- Firms and organizations in your cluster . .

Note: August 2001, n=40
Source: Clusters of Innovation Initiative Regional Survey

Institutions for Collaboration. Like the Research Triangle in general, the business environment of the pharmaceutical / biotechnology cluster was marked by the presence of large pharmaceutical companies, but also a lack of start-up business expertise and capital in the 1970s and 1980s. For example, when Sphinx Pharmaceutical was founded, they were unable to rely on local talent or local money. The North Carolina Biotechnology Center and the Council for Entrepreneurial Development changed this. Interviewees consistently cited the North Carolina Biotechnology Center and the Council for Entrepreneurial Development as important to the cluster's success, not only because they link firms to research and talent inside the universities, but also because they give firms access to business knowledge and venture capitalists. Forty-eight percent of survey respondents reported that institutions for collaboration were helpful to entrepreneurial firms, but only 26.7% said it was helpful to established firms—a further breakdown of responses is given in Exhibit 63 below. The North Carolina Biotechnology Center and the Council for Entrepreneurial Development have been especially helpful for the pharmaceutical / biotechnology cluster, and any weakening of their effectiveness would disproportionately affect this cluster.

Exhibit 63: Survey Results for Institutions for Collaboration, Research Triangle Pharmaceutical / Biotechnology Cluster

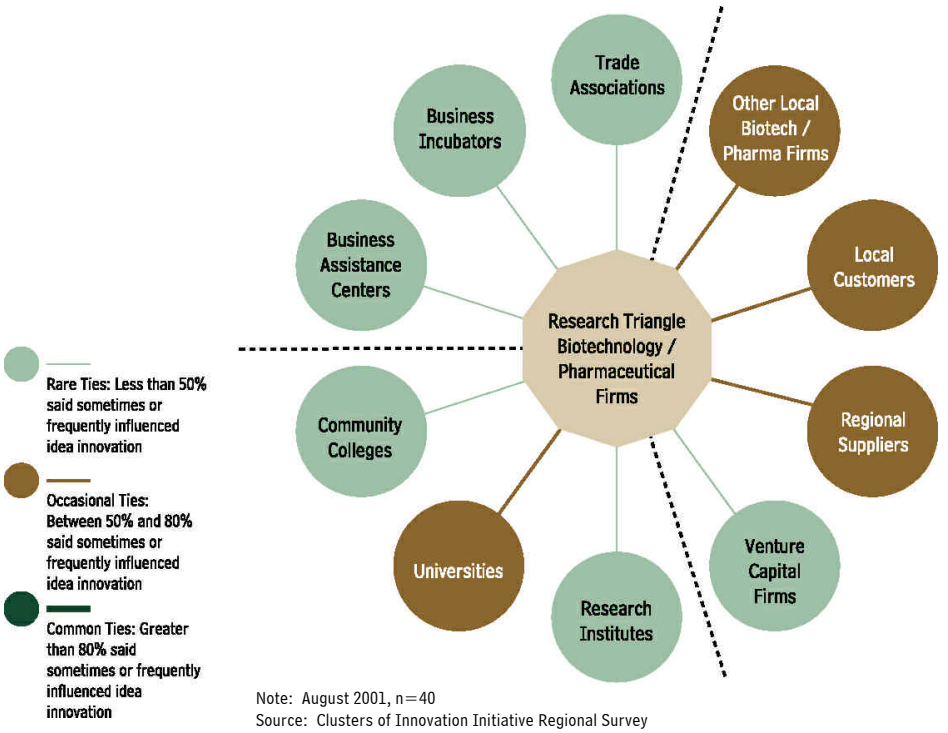


Source: Clusters of Innovation Initiative Regional Survey

The cluster also faced a complicated regulatory environment and inattentive local government in the 1990s. Interviewees reported that the North Carolina Biotechnology Center and the Council for Entrepreneurial Development have been effective in helping with regulatory and legislative issues, and community educational outreach. According to an industry executive, "the Council for Entrepreneurial Development in particular has something for everyone: capital gets access to potential deal-flow, service providers get access to potential clients, companies get mentoring and advice, and scientists get access to industry leaders. The Council for Entrepreneurial Development has also had a number of big successes over the years which gives them credibility, they are perceived as being effective, and hence can get the participation that makes them effective. Finally, they have great leadership.[86] As for the North Carolina Biotechnology Center, one biotechnology CEO added, "the North Carolina Biotechnology Center is instrumental in helping local biotechnology start-ups. They are usually more useful for start-ups, but they are also very important to the larger players because they help coordinate training programs with the local Community colleges.[87] Fifty-five percent of the biotechnology executives we surveyed stated their industry associations were effective at advocating public policies.[88]

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 64 below summarizes survey findings of interaction on idea generation. According to our survey, pharmaceutical / biotechnology executives are somewhat concerned about insufficient interaction with their local customers; 60% state that improving the quality of transportation is a future threat if not addressed. This was the greatest concern, along with lowering the costs of doing business.

Exhibit 64: Strength of Linkages, Pharmaceutical / Biotechnology Cluster, Research Triangle



Note: August 2001, n=40
Source: Clusters of Innovation Initiative Regional Survey

CONCLUSION

The Research Triangle's pharmaceutical / biotechnology 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 human 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 the Research Triangle Institute and the North Carolina Biotechnology Center to facilitate knowledge transfer and concentrate business know-how. Second, building the cluster required sustained commitment; bioscience research centers were established by 1980, but the cluster did not take off until the late 1990s. Third, high quality specialized inputs—and in particular human assets—were vital for growing the knowledge-intensive the pharmaceutical / biotechnology cluster in the Research Triangle. Fourth, geographic proximity—in this case clustering on the Research Triangle Park—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, the University of North Carolina-Chapel Hill, Duke University, North Carolina State University, and the institutions for collaboration 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,

GlaxoSmithKline was critical to the formation of the pharmaceutical / biotechnology cluster in the Research Triangle. Eighth, the EA allows for a more comprehensive and relevant analysis of the pharmaceutical / biotechnology cluster than the MSA.

THE COMMUNICATIONS EQUIPMENT CLUSTER IN THE RESEARCH TRIANGLE

Nationally, the communications equipment 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. 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 equipment cluster is broadly distributed nationally. The area with the highest share of national cluster employment is in the San Jose metropolitan area, which has 7.16% of the national communications equipment employment. Other important metropolitan areas include Boston, Chicago, and Washington, DC.

In the Research Triangle MSA, the communications equipment cluster ranked 17th in total employment, with approximately 49,455 workers in 1999 (broad cluster definition). As an EA, the region ranked seventh in total employment, with approximately 11,626 workers in 1999 (narrow cluster definition). Its performance in terms of patent registration is above average for the nation, and comparable to other leading communications equipment clusters around the country. The Research Triangle cluster grew in response to increasing demand for communications equipment technology. It is composed of many well-known companies focused on commercial applications. Anchored by IBM, Nortel Networks, and Cisco Systems, the Research Triangle has become a world-leading center in telecommunications. In recent years, major international companies such as Cisco 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 local universities) and the sophisticated multinationals with local operations — like IBM and Nortel Networks — were critical to cluster development. The local related and supporting industries and the context for firm rivalry and strategy have been neither advantages nor disadvantages.

Development of the Research Triangle's Communications Equipment Cluster

Since the 1980s, the Research Triangle has been a center for the development of communications equipment technology. Initially, the region focused on networking applications related to computers and their connections to each other. Electronics and communication expertise grew up in the region as major multinationals like IBM began to establish manufacturing operations in the Research Triangle focusing on information technology.

Other communications equipment powerhouses, including Nortel Networks, Alcatel, Cisco Systems, and Sumitomo Electric, eventually joined IBM. Sumitomo Electric, a supplier of optical fiber cable and related products to the telephone, CATV, utility, long distance, and datacom markets, exemplifies the typical communications equipment company with operations in the Research Triangle Park.

Microelectronics was supposed to become a significant industry in the Research Triangle Park, through developments at existing organizations such as the Research Triangle Institute, plus a mix of new recruits. The centerpiece of the state's initiatives in the field, the Microelectronics Center of North Carolina, was conceived as a specialized research and development institute and launched in 1980 with funds from the General Assembly. The Microelectronics Center of North Carolina eventually migrated into more communications-centric research work, eventually partnering with a variety of customers to develop and apply communications equipment technologies with commercial value. For example, Cronos Integrated Microsystems owes its origins to the Microelectronics Center of North Carolina. In April 1999, the MEMS Technology Applications Center spun off from the Microelectronics Center of North Carolina and became Cronos, a for-profit company. Just one year later, JDS Uniphase, a fiber optics component supplier, acquired Cronos in a stock transaction worth more than $750 million dollars. Since the Microelectronics Center of North Carolina owned a third of Cronos, its stake was worth $250 million.

In 1982, a small but influential trade group, the Semiconductor Research Corporation, opened to coordinate and direct university research. Yet neither really lured a major chip plant to the region and the semiconductor effort slowly faded away. Nevertheless, for a brief time period, another large multinational, General Electric, chose the area for a major plant. After scouting sites for months in a corporate jet packed with files and decision-makers, General Electric chose the Research Triangle Park for a research and fabrication facility focusing on advanced electronic devices. Some of these devices spilled over into communications-related areas.

It was one of the park's international recruits, however, that eclipsed all the chip companies combined in terms of long-term development. Northern Telecom (now Nortel Networks), based in Toronto, chose the Research Triangle Park for its United States subsidiary. What Burroughs Wellcome had done for the local pharmaceutical scene, Northern Telecom did for the Research Triangle's communications equipment cluster. Nortel also matched IBM's presence in terms of sheer work force—manufacturing switch systems around the clock—and by continual construction of new facilities.[89]

Alongside efforts in the Research Triangle Park to recruit major corporations to the area, North Carolina State University began to emerge as the lynchpin of the region's growing involvement in communications-related activities. On December 19, 1984, North Carolina State University alumnus Governor James B. Hunt, Jr. transferred 780 acres of state-owned land to the university, effectively doubling North Carolina State University's size. Centennial Campus was carved out of part of this land and was intended to formalize principles that had emerged through the development of the original campus over 100 years. The new campus was to be composed of "related villages, neighborhoods and courtyards" that were defined by studies, services, interaction, natural landscape, recreation, open spaces, and focal points—in effect, a city of neighborhoods.[90]

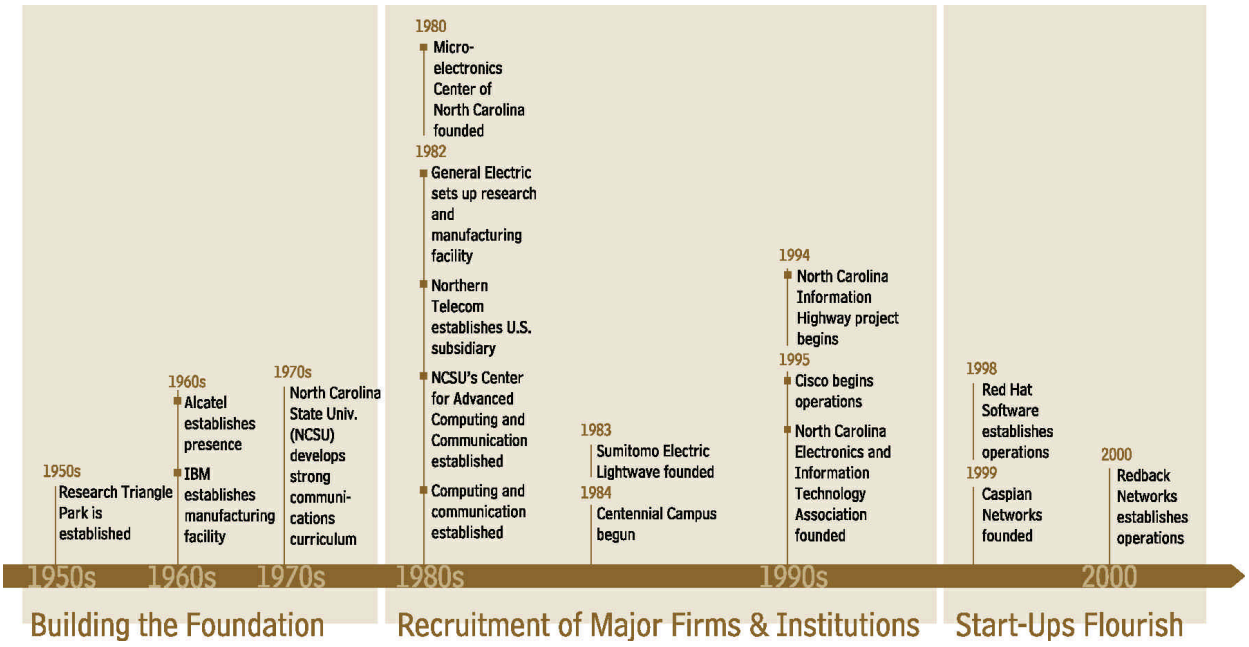
In the early 1990s, the Research Triangle became increasingly associated with the development of communications equipment technology. Thus, even though IBM went through a massive downsizing in 1993 to 1995, its Research Triangle Park work force survived almost unscathed. The park became the central location for the company's growing personal computer and networking operations while its other sites struggled with products and services less in demand (See Exhibits 65 and 66 on the following page).

Exhibit 65: Communications Equipment Cluster Timeline, Research Triangle Region

Historical Obstacles	Important Enablers	Key Events
☐ Lack of local venture capital	☐ Government R&D funding	☐ Establishment of Research Triangle Park
☐ Lack of major locally-headquartered company	☐ Nortel and Cisco became anchor firms for the cluster	☐ Increase in IBM presence beyond PCs
☐ Lack of specialized technology management expertise	☐ Construction and operation of the North Carolina Information Highway	☐ Nortel relocation to Research Triangle
☐ Lack of image as a cosmopolitan business center	☐ Good quality of life	☐ Establishment of Cisco's operations
		☐ Establishment of the Center for Advanced Computing and Communication
		☐ Sale of Cronos to JDUniphase

Source: Clusters of Innovation Initiative Regional Survey™ Data and In-Person Interviews

Exhibit 66: Research Triangle Communications Equipment Cluster Timeline



By the mid 1990s the cluster began to achieve a critical mass with the establishment of Cisco's East Coast operations in the Research Triangle Park. Cisco, a leader in networking for the Internet, employs about 3,000 people in the Triangle. Of Cisco's local employees, about 65% are engineers in customer and technology support and software and hardware development. The remaining 35% are resource positions, such as public relations and human and work place resources.[91]

Cisco Systems reportedly picked the Research Triangle Park because of the proximity to IBM's massive operation and to bolster ties to East Coast corporations. Cisco's Research Triangle Park headquarters

helped facilitate joint ventures with IBM and helped address the integration of SNA-based computer networks that use mainframes with non-SNA local (LAN) and wide (WAN) area networks.[92] As mentioned by an industry executive, "Cisco came to the Research Triangle Park because of several factors: the political leadership, especially that of Governor Hunt, made it easy to come here; the universities, and thus talent, was here; the quality of life was great; and IBM had the right types of business units here."[93] Personal ties also influenced the decision: Chief Executive John Chambers is a Duke University law-school graduate. All in all, approximately 16 different Cisco businesses have operations at the Research Triangle Park, including its largest customer service center.[94]

Not Just Networking Equipment. The networking equipment sub-cluster of the communications equipment cluster has for many years had a sizeable presence in the Research Triangle with Nortel Networks and Cisco Systems operating large facilities there. However, two giants of the telecommunications services industry have also grown in the Triangle. Both AT&T Solutions, the professional services division of AT&T, and MCI WorldCom Inc., are managing the networks of large global companies from operations based in the Triangle.

The AT&T Global Client Support Center in Durham—one of three in the United States—houses more than 500 employees who custom manage the communications and workflow of close to 400 companies, including Merrill Lynch, AlliedSystems, and General Motors. In Cary, MCI WorldCom employs 3,300 people who manage the networks and Internet businesses of companies such as United Parcel Services, Electronic Data Systems, and the United States Postal Service.

MCI WorldCom's Cary center — also one of three in the country — is known as the heartbeat of the company's entire network. Employees in the three buildings off Weston Parkway monitor all the distribution network and communications for the United States Postal Service, and they also manage the satellite systems and global networks of the Federal Aviation Administration. A $650 million, 10-year contract was inked last year with BP Amoco to manage all of the petroleum company's communications with oil suppliers, distribution, and network support.

Most of these contracts are customized, meaning MCI WorldCom and AT&T Solutions will also manage the distribution, purchasing cycles and e-business for companies such as Citibank, BP Amoco, and Coca Cola Company. AT&T, for instance, uses a Global Enterprise Monitoring System to manage more than 20 million transactions for MasterCard each day, an average of $500 million in debits daily. And for McGraw-Hill, a publishing company in New York, AT&T is developing a technology that will enable the company to send major clients volumes of material electronically, saving significant sums on their huge shipping costs.[95]

More recently, the same characteristics that attracted San Jose-based Cisco Systems here in 1995 are still attracting Silicon Valley-based companies. In the past year, three Silicon Valley-based companies have opened engineering and development outposts here and one start-up has emerged. Along with Lucent, both Nortel Networks and Alcatel are engaging in work related to optical networking at their Research Triangle facilities. Optical-related firms now have a substantial presence in the Research Triangle, having been lured by the area's existing talent and two universities with specialties in the optical networking and engineering fields. For example, North Carolina State University is consolidating its photonics research into one lab while Duke University recently received a $25 million gift to start a photonics lab.[96]

Caspian Networks, which builds optical IP switches, considered Northern Virginia and Minneapolis but chose the Research Triangle because of the presence of IBM and Cisco and its excellent quality of life.[97] Caspian Networks was founded last June with an $85 million investment led by Merrill Lynch. It is using the money to develop an optical switch to make the Internet a fast-enough medium for delivering video and phone service more effectively than other technologies. Also, last year Redback Networks Inc., a highly touted Silicon Valley optical networking company, established a presence in the area after having considered Boston and the Washington, D.C. area before locating in the Research Triangle Park for much the same reasons as Caspian Networks. Redback Networks is a publicly traded company that provides services to cable operations and carriers installing broadband access. One of its products is a platform for carriers using optical technology.[98] Established telecom players are also using their Triangle facilities to develop more optical expertise. At Alcatel, the French-based company is developing its fiber-to-the-home product in Raleigh.

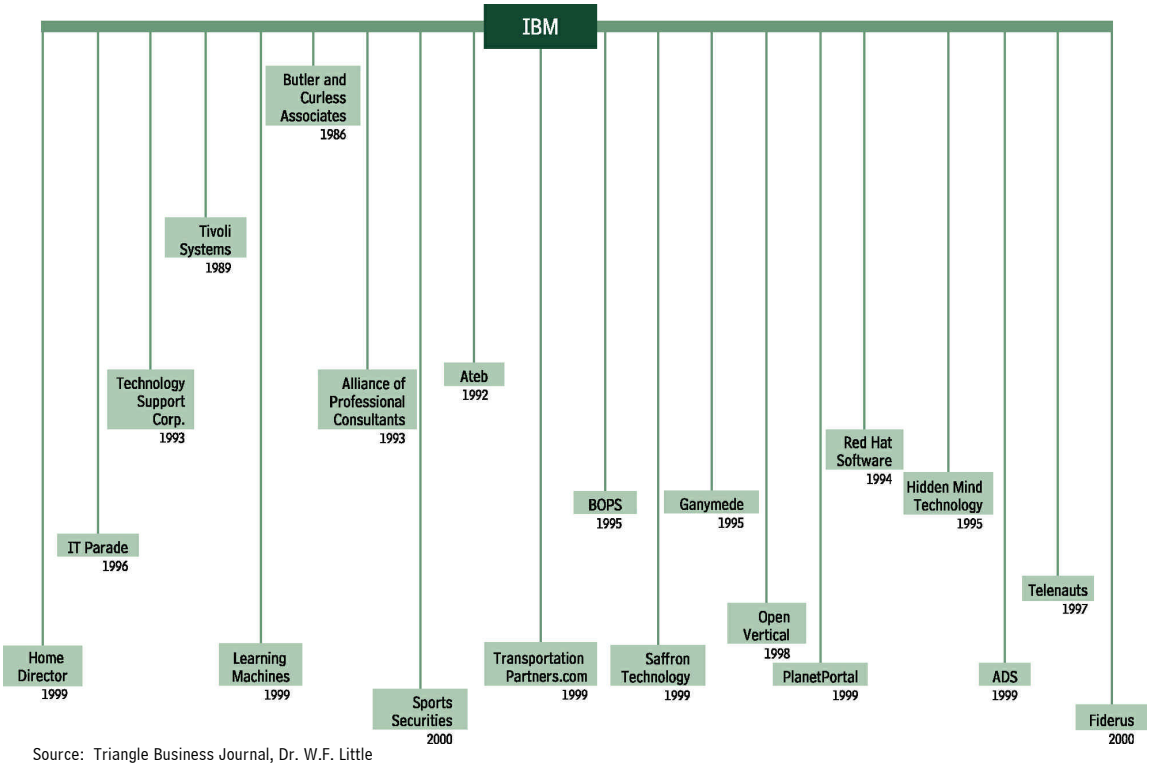
Most of the companies engaged in optical work are outposts of existing companies. However, at least one company is locally based. OptXcon is a start-up working to bring an optical "cross connect" to market. Optical cross connects route the light waves carrying information over fiber optic networks to the correct destination. The company has landed $12.2 million in venture capital from Corning (a maker of optical-network gear) and other firms. Even though the CEO was most recently living in California, is not from the Research Triangle region, and had the option of locating the company virtually anywhere, he chose to base his company in the Triangle due to quality of life, cost of living, access to premier education institutions, and a technologically advanced work force.[99]

Gradually, over the course of 20 to 30 years, the Research Triangle has become a national center for networking communications equipment. Cisco, Nortel and others have made the Research Triangle their site for a large portion of their East Coast United States networking business. The region is now well established as having a major national communications equipment cluster with a particularly strong presence in networking communications technology. IBM has also contributed as an anchor company for the cluster. A number of spin-offs have emanated from IBM in the last two decades, much the same as GlaxoSmithKline (see Exhibit 67 on next page).

RECENT ECONOMIC PERFORMANCE

The Clusters of Innovation Initiative assessed the Research Triangle's regional economy using the MSA broad cluster definition, and, in cases where it is warranted, the Economic Area EA narrow cluster definition. Broad and narrow cluster definitions of the MSA and EA can be explained as follows. Clusters are made up of industries. Some industries are core to a cluster. For example, x-ray devices is core to the medical devices cluster. But these same industries are also of secondary importance to other clusters; x-ray machines are also part of, but not core to, the analytical instruments cluster. Thus, a narrow cluster classification only incorporates core industries, while a broad cluster classification includes industries that are both core and of secondary importance. MSA broad cluster definition can be thought of as being similar to the conventional wisdom in a region for a particular industry, while an EA narrow cluster definition is but another way that provides important and valuable insight.

Exhibit 67: Anchor Companies, Development of the Communications Cluster, Research Triangle



Source: Triangle Business Journal, Dr. W.F. Little

Exhibit 68: Communications Cluster, Leading MSAs by Total Employment, Broad Cluster Definition

Metropolitan Area	1999 Total Employment	Employment CAGR 1990–1999	Establishments CAGR 1990–1999	1999 Average Wages	Patents per 1000 Employees 1998	CAGR of Patents 1990–1998
San Jose, CA	237,927	1.4	7.2	$95,671	13.2	17.2
Boston-Worcester-Lawrence-Lowell-Brocktn, MA-NH	214,129	0.7	6.8	$68,386	5.8	5.6
Chicago, IL	158,390	1.3	7.1	$55,783	5.0	6.7
Washington, DC-MD-VA-WV	130,942	5.6	9.4	$66,994	3.8	3.6
Los Angeles-Long Beach, CA	122,844	-4.0	4.2	$53,545	5.2	9.7
Dallas, TX	104,270	2.5	7.9	$66,056	7.5	9.2
Orange County, CA	95,861	0.3	5.6	$56,149	4.8	9.7
San Diego, CA	71,058	3.3	8.7	$79,864	7.1	5.7
Seattle-Bellevue-Everett, WA	64,222	4.4	8.8	$98,275	9.0	11.3
Philadelphia, PA-NJ	61,854	0.2	6.0	$59,639	4.9	6.7
Minneapolis-St. Paul, MN-WI	61,060	1.9	9.5	$52,108	9.1	7.1
Phoenix-Mesa, AZ	57,854	1.2	8.4	$54,620	10.8	13.4
New York, NY	55,262	0.7	7.6	$67,004	11.2	9.9
Atlanta, GA	52,877	4.8	12.1	$66,449	5.5	9.8
Austin-San Marcos, TX	51,541	6.7	11.4	$63,711	23.8	17.5
Oakland, CA	50,019	5.5	10.7	$71,751	13.6	11.0
Raleigh-Durham-Chapel Hill, NC	49,455	2.2	11.9	$57,260	7.6	18.0
Portland-Vancouver, OR-WA	48,249	6.0	9.0	$59,902	10.6	8.4
San Francisco, CA	47,307	6.1	8.4	$97,581	15.9	11.1
Nassau-Suffolk, NY	44,556	-3.4	4.0	$57,410	5.1	9.3

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

Employment. In 1999, there were 49,455 employees in the Research Triangle MSA communications equipment cluster (broad cluster definition). This was 1.49% of total national employment in communications equipment and made the Research Triangle the 17th most concentrated cluster out of the 20 largest MSAs in communications equipment in the United States.[100] The region's 2.2% annual growth rate over the 1990 to 1999 period was the tenth fastest among the 20 largest clusters. (See Exhibit 68.)

Exhibit 69: Communications Cluster, Leading EAs by Total Employment, Narrow Cluster Definition

Economic Area	1999 Total Employment	Employment CAGR 1990–1999	Establishments CAGR 1990–1999	1999 Average Wages	Patents per 1000 Employees 1998	CAGR of Patents 1990–1998
San Francisco-Oakland-San Jose, CA	45,400	4.6	6.3	$114,474	27.6	10.6
Boston-Worcester-Lawrence-Lowell-Brockton, MA-NH-RI-VT	41,857	-0.9	4.8	$66,121	8.7	5.9
Chicago-Gary-Kenosha, IL-IN-WI	41,168	-2.3	1.0	$32,147	8.5	9.6
New York-N. New Jersey-Long Island, NY-NJ-CT-PA-MA-VT	38,583	-3.5	1.8	$49,901	22.7	10.6
Los Angeles-Riverside-Orange County, CA-AZ	33,410	0.0	1.5	$55,858	12.4	5.8
Dallas-Forth Worth, TX-AR-OK	30,217	3.8	2.5	$57,546	12.9	9.1
Raleigh-Durham-Chapel Hill, NC	11,616	0.6	0.9	$57,255	10.9	18.9
Washington-Baltimore, DC-MD-VA-WV-PA	10,076	2.2	4.5	$59,462	21.4	5.1
Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD	10,048	-1.8	2.2	$50,831	10.0	4.8
Fort Wayne, IN	8,798	0.2	3.3	$29,257	1.1	6.9
Phoenix-Mesa, AZ-NM	8,571	-3.0	3.7	$59,564	26.2	16.7
Atlanta, GA-AL-NC	8,007	-5.3	4.9	$45,199	2.2	17.5
Miami-Fort Lauderdale, FL	7,034	-1.9	6.8	$30,072	14.5	5.4
Rochester, NY-PA	6,897	0.3	2.3	$41,809	23.7	5.6
San Diego, CA	6,660	2.0	3.8	$43,243	24.4	7.3
Hickory-Morganton, NC-TN	6,575	9.6	6.3	N/A	2.2	0.3
Minneapolis-St. Paul, MN-WI-IA	6,526	-3.7	3.2	$46,681	18.1	8.6
Syracuse, NY-PA	6,413	-3.8	-0.9	$28,441	10.6	12.8
Omaha, NE-IA-MO	4,827	-2.5	3.9	N/A	1.0	4.9
Denver-Boulder-Greeley, CO-KS-NE	4,814	-1.9	4.8	$60,413	38.4	16.8

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

In 1999, there were 11,616 employees in the Research Triangle EA communications equipment cluster (narrow cluster definition). This was 2.6% of total national employment in communications equipment, and made the Research Triangle the seventh most concentrated cluster out of the 20 largest EAs in communications equipment in the United States.[101] The region's 0.6% annual growth rate over the 1990 to 1999 period was the sixth fastest among the 20 largest clusters. (See Exhibit 69.)

Average Wages. In 1999, the Research Triangle MSA's average wage of $57,260 ranked it 15th among the 20 largest national communications equipment regions (broad cluster definition). Wages grew at an average of 7.0% annually from 1990 to 1999 in the MSA, tenth fastest among the 20 largest clusters as an MSA, but still below that of other leading communications equipment clusters. When compared to average wages in communications equipment nationwide, the Research Triangle MSA pays about 3.5% less.

In 1999, the Research Triangle EA's average wage of $57,255 ranked it seventh among the 20 largest national communications equipment regions (narrow cluster definition).

Patent Registration. In 1999, the Research Triangle MSA (broad cluster definition) communications equipment firms and institutions registered 375 patents, representing 1.5% of total United States communications equipment cluster patents. This is slightly lower than we would expect since the Research Triangle MSA employs 1.5% of the nation's communications equipment workers. Out of the 20 largest communications equipment regions, the Research Triangle ranks tenth in patents per employee as an MSA, with 7.6 per 1000 employees. The top MSAs in 1998 in patents per employee were the Austin and San Francisco metro areas, with rankings of 23.8 and 15.9 respectively.

The Research Triangle MSA's 18.0% annual growth rate in patents since 1988 was the fastest among top 20 regions. The large number of communication firm start-ups based on new technology, the presence of Cisco, Nortel, and Ericsson, and the continued expansion of IBM suggest that this positive innovation trend will continue. IBM, for example, had 374 patents between 1994 and 1998, tops among the region, and the next highest, Ericsson, had 148 during the same period.[102]

The communications equipment cluster in the Research Triangle does well in terms of cited patents as well. It had 292 cited patents per 1000 employees in 1998, which was roughly 42% above the national average for the cluster.

In 1998, the Research Triangle EA (narrow cluster definition) communications equipment firms and institutions registered 141 patents, representing 1.8% of total United States communications equipment cluster patents. This is slightly lower than we would expect since the Research Triangle EA employs 2.64% of the nation's communications equipment workers. Out of the 20 largest communications equipment regions, the Research Triangle ranks 13th in patents per employee as an EA, with 10.9 per 1000 employees. The top EAs in 1998 in patents per employee were the Denver-Boulder-Greeley, Colorado-Kansas-Nebraska and San Francisco-Oakland-San Jose, California economic areas, with rankings of 38.4 and 10.6 respectively. The Research Triangle EA's 18.9% annual growth rate in patents per 1000 employees since 1990 was fastest among top 20 regions.

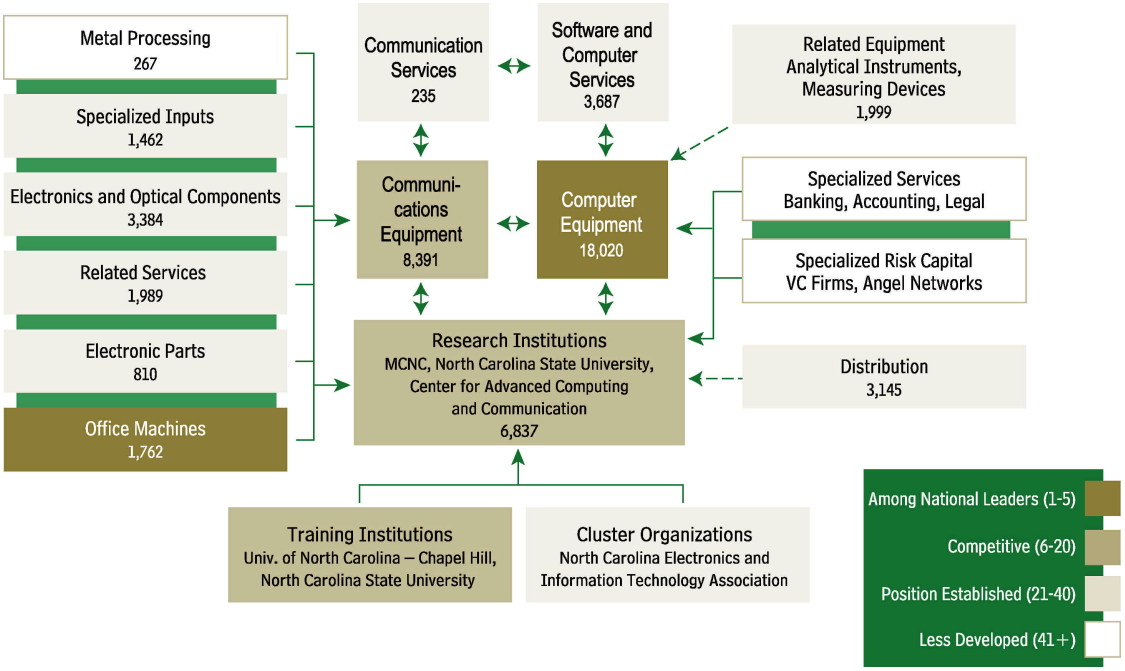
Investments/VC Funding. According to PriceWaterhouseCoopers Money Tree database, the Research Triangle communications equipment firms raised $30.9 million in venture capital funds from 1995 to 1999, or 0.3% of the national total over this period.[103]

DESCRIPTION OF THE REGIONAL COMMUNICATIONS EQUIPMENT CLUSTER

The competitive position of the Research Triangle EA communications equipment cluster is shown in Exhibit 70. Five boxes (Specialized Services, Specialized Risk Capital, Training Institutions, and Cluster Organizations) represent related organizations and institutions that are important components of the Research Triangle communications equipment 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 Research Triangle communications equipment cluster includes leading firms in electronics, routing technology, and Internet communication devices as well as some communications software developers. Large employers include Cisco, Nortel, IBM, Ericsson, and Alcatel. Fast growing small firms include Caspian Networks, a provider of optical IP switches, and Redback Networks, a leading designer of data communications equipment. The Research Triangle communications equipment firms typically maintain their corporate offices, research operations, and product development facilities in the Research Triangle.

Exhibit 70: Competitive Position, Communications Equipment Cluster, Research Triangle EA



Note: Employment numbers are given inside boxes where available
Source: Regional Survey Data, Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School and In-person Interviews

Exhibit 71 on the following page shows the relative size and growth of the sub-clusters within the Research Triangle. The communications equipment and office machines are among national leaders, while research and training institutions and communications equipment are all relatively competitive. Specialized inputs, electronics and optical components, electronic parts, communications services, computer related services, related equipment (e.g., analytical instruments and measuring devices), distribution, and cluster organizations are among the sub-clusters considered to have an established position. Computer equipment, office machines, and electronic computers in communications have an unusually high share of the industry national percentage due to the presence of IBM and Cisco. Only one sub-cluster in the communications equipment cluster in the Research Triangle (metal processing) had national shares less than the regional average of 0.57% in 1999.

At an industry level, the drivers of the sub-cluster performance become evident (see Exhibit 71). The electronic computers industry (driven by IBM and Cisco) posted strong national participation rates as did office machines, n.e.c., and telephone and telegraph apparatus industries. No industries have been declining rapidly.

CLUSTER INNOVATIVE CAPACITY

Our analysis indicates a strong innovation environment has emerged, based primarily on research and development by established communications equipment multinationals, a highly trained labor force, and nascent university-business linkages.

Specialized Educational Institutions and Talent Pool. The Research Triangle is home to a comparatively large number of skilled workers in the communications equipment cluster. According to the Bureau of Labor Statistics, in 1998 (the most recent year available) there were 4,480 electrical or electronic engineers and more than 2,900 electrical or electronic engineering technicians in the region.

In recent years, the Research Triangle has improved its academic and training infrastructure to support specialized research in communications equipment related fields. For example, the optical networking companies are developing partnerships with educators to train technicians to support their growth. Nortel premiered its Optical Internet Technology training program that it is offering in conjunction with Wake Technical Community College. Students who successfully complete the 15-week pilot program, held at the Raleigh Technical Education Center, a Nortel facility, can become candidates for Nortel certification and employment.

Competitor Cisco offers its own brand of optical network training through its Networking Academy Programs. In recent years Cisco has enrolled students in classes at community colleges, high schools, homeless shelters and juvenile centers, and near military installations for outgoing personnel.[104] These private-sector initiatives are complemented by substantial investments by the universities. In general, communications equipment cluster companies have been very involved in boosting the region's educational focus on communications equipment with its program of networking academies in high schools, community colleges, and four-year colleges and universities. Networking academies have been established in 70 of North Carolina's 100 counties by Cisco alone.[105]

Most Research Triangle communications equipment executives are not concerned about future access to employees. Nine percent of the executives surveyed reported that the supply of scientists and engineers

Exhibit 71: Communications Equipment Sub-Clusters, Research Triangle MSA, 1999

Sub-Cluster	Narrow or Broad	SIC	Label	National Percentage Share 1999	Total Employment 1999
Communications Cluster				1.5	49,455
Communications Equipment*	Narrow	3661	Telephone and telegraph apparatus	3.7	3,798
	Narrow	3663	Radio and TV communications equipment	2.9	4,014
	Narrow	3669	Communications equipment, n.e.c.	0.0	0
Specialized Inputs*	Narrow	3357	Nonferrous wiredrawing and insulating	0.3	193
	Narrow	3629	Electrical industrial apparatus, n.e.c.	0.9	159
	Narrow	3671	Electron tubes	0.1	10
	Narrow	3676	Electronic resistors	5.4	550
	Narrow	3678	Electronic connectors	0.0	0
Office Machines	Narrow	3579	Office machines, n.e.c.	9.1	1,705
Communications Services	Broad	4820	Telegraph and other communications	0.7	5
	Broad	4890	Communication services, n.e.c.	0.5	187
Related Services	Broad	7377	Computer rental and leasing	0.8	112
	Broad	7379	Computer related services, n.e.c.	0.8	1,719
Electronic and Optical Components	Broad	3644	Noncurrent-carrying wiring devices	0.0	0
	Broad	3672	Printed circuit boards	0.2	164
	Broad	3674	Semiconductors and related devices	0.4	770
	Broad	3677	Electronic coils and transformers	1.3	240
	Broad	3679	Electronic components, n.e.c.	0.9	1,663
	Broad	3695	Magnetic and optical recording media	0.4	60
	Broad	3827	Optical instruments and lenses	0.1	10
Software and Computer Services	Broad	7372	Prepackaged software	0.8	2,359
	Broad	7375	Information retrieval services	0.8	840
	Broad	7376	Computer facilities management	0.5	338
Metal Processing	Broad	3325	Steel foundries, n.e.c.	0.0	0
	Broad	3351	Copper rolling and drawing	0.0	0
	Broad	3356	Nonferrous rolling and drawing, n.e.c.	0.0	7
	Broad	3365	Aluminum foundries	0.0	0
	Broad	3463	Nonferrous forgings	0.1	10
	Broad	3469	Metal stampings, n.e.c.	0.1	60
Cabinets	Broad	2517	Wood TV and radio cabinets	0.0	0
Power Transmission Equipment	Broad	3568	Power transmission equipment, n.e.c.	0.0	0
Electronic Parts	Broad	3643	Current-carrying wiring devices	1.7	750
	Broad	3691	Storage batteries	0.	60
Computer Equipment	Broad	3571	Electronic computers	20.1	17,580
	Broad	3572	Computer storage devices	0.9	375
	Broad	3577	Computer peripheral equipment, n.e.c.	0.1	65
Related Equipment	Broad	3651	Household audio and video equipment	0.2	60
	Broad	3761	Guided missiles and space vehicles	0.0	0
	Broad	3810	Search and navigation equipment	0.0	10
	Broad	3825	Instruments to measure electricity	1.3	814
	Broad	3826	Analytical instruments	0.4	129
	Broad	3829	Measuring and controlling devices, n.e.c.	2.1	750
Research Institutions	Broad	8731	Commercial physical research	2.2	5,115
	Broad	8733	Noncommercial research organizations	2.0	1,683

Note: Gold shading indicates industry with a higher than expected concentration (i.e., 0.57% of the nation's employment)
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

in the region was too scarce to meet their expansion needs, with more than 60% reporting that the supply of skilled workers was adequate.[106] This compares favorably to survey responses from other regions.

Specialized Research Centers. While nearly 87.9% of survey respondents reported ready access to local research centers, only 63% expressed satisfaction with the level of knowledge transfer to their industry; 24% said these research institutions rarely transferred knowledge.[107] 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.

Area universities have aided the communications equipment cluster's growth by being able to develop programs and curricula—i.e. a master's of networking degree at North Carolina State University—that have responded to the ever-changing needs of the industry. North Carolina State University also has the Center for Advanced Computing and Communication, a National Science Foundation Industry/University Cooperative Research Center for advanced computer and communication systems. The Center for Advanced Computing and Communication was originally founded in 1982 as the North Carolina State University Industry/University Cooperative Research Center for Communications and Signal Processing. In 1994 the Center incorporated a second research site at nearby Duke University and changed its name to reflect this new partnership.

The Center for Advanced Computing and Communication's mission is to carry out basic and applied research on the telecommunications sector and to transfer these results to contributing members such as Alcatel, BellSouth, Cisco Systems, Ericsson, General Dynamics, IBM, Nortel Networks, KLA-Tencor, Lucent Technologies, Stratus Computer, and Telcordia Technologies. Government agency sponsors are the National Science Foundation, Naval Surface Warfare Center, and the National Security Agency.

Context for Firm Strategy and Rivalry. The Research Triangle communications equipment cluster exhibits rapid growth of new firms, moderate competitive rivalry, and sporadic collaboration among firms. According to the national mapping database, 609 net new establishments were created in the cluster in the Research Triangle MSA (broad cluster definition) from 1990 to 1999. The Research Triangle's ranking against the 20 largest communications equipment MSAs moved to 17th in 1999 in terms of its total number of establishments from 19th in 1990.[108]

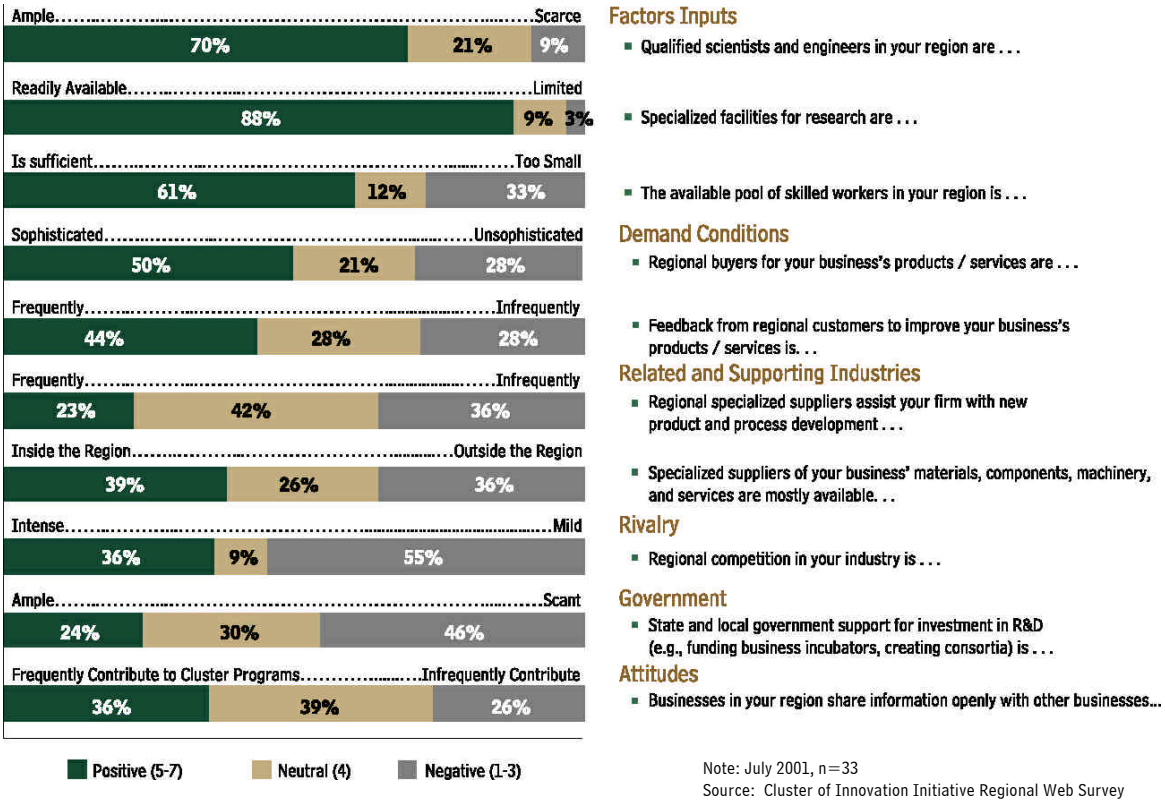
Thirty-six percent of survey respondents described competition in their cluster as intense, while 55% called it mild. Moreover, 47% claimed there were average to few firms competing locally. Response rates were low relative to other regions for the first question and slightly higher for the second question. Executives in the Research Triangle communications equipment cluster have mixed views about the amount of firm-level collaboration that exists in the region, but in general, there is a palpable sense of cooperation. One local executive comments, "The attitudes of locals is critical. Attitude among CEOs and even investors is pretty open with the norm being that you have to 'check your guns at the door.' VCs that compete with each other and service providers that compete (accountants, lawyers, consultants) are expected to come, look at a company's proposal, offer advice, compete to fund it or make it a client. In fact, companies have said they are 'amazed' at what VCs will tell them even if that VC chooses not to fund them."[109]

Sophistication of Regional Demand. The presence of major communications equipment companies continues to be an asset boosting local demand, with Research Triangle communications equipment executives expressing positive views about the level and sophistication of interaction with their local cus-

tomer base. Fifty percent of survey respondents said that their regional customers spur them to create new products and services, compared to the 18% average of other regions studied. Twenty-eight percent of the region's communications equipment executives expressed a desire to obtain more frequent feedback from their customers about product offerings, compared to 26% average across other regions studied.[110]

Related and Supporting Industries. Research Triangle communications equipment executives expressed satisfaction with their access to specialized suppliers, and feel regional suppliers provide the cluster firms with a competitive advantage. Forty-one 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 39% said they can source most of their inputs from sources within the region. A substantial minority of 36%, however, reported that they frequently go outside the region for supplies.[111] About 35% of the respondents consider their specialized suppliers as frequent contributors to their innovation efforts, slightly below average across all regions studied of 38%.[112] (See Exhibit 72 below.)

Exhibit 72: Select Survey Results, Communications Cluster, Research Triangle



Note: July 2001, n=33
Source: Cluster of Innovation Initiative Regional Web Survey

Government. As noted earlier, government actions have been important contributors to the growth of innovative capacity in the cluster, primarily through federal funding of R&D and state funding of colleges and universities such as the University of North Carolina-Chapel Hill and North Carolina State University.

Government has been somewhat helpful in spurring local demand for telecommunications gear and services with the state's creation of the North Carolina Information Highway in 1994. The North Carolina Information Highway included the implementation of advanced switches and other technologies to allow data to be received at participating sites at high speeds. The system provided true two-way video communications equipment, along with data transmission for distance learning for schools and colleges, telemedicine at rural clinics, and corporate videoconferencing and training. This statewide digital network serving both data and voice communications –the first in the nation to do such an undertaking—was really first established in the mid-1980s when the state government requested that the three major telephone companies in North Carolina (Bell South, Carolina Telephone, and GTE) submit proposals for the construction of a statewide optical-fiber-based network using SONET/ATM technology.

Today the initiative has evolved into the backbone for the statewide broadband communications network. The state is the principal customer of this network and pays a usage fee to the providing telephone companies. This type of forward thinking gave rise to large, private-sector companies becoming more and more interested in setting up a presence in the area. This project involved implementing some of the latest communications equipment available at the time, further spurring local demand for communications equipment and resources. With these types of initiatives, the state has proven to be a sophisticated consumer of communications equipment.

Nevertheless, communications equipment executives tend to agree with general concerns that local governments have difficulty coordinating to meet region-wide challenges such as improving physical infrastructure, or even provide sufficient support for R&D investment in the communications equipment cluster. Forty-six percent of the region's survey respondents indicated that state and local government support for investment in R&D (e.g. funding business incubators, creating consortia) has been scant. This compares unfavorably to survey results across all regions.

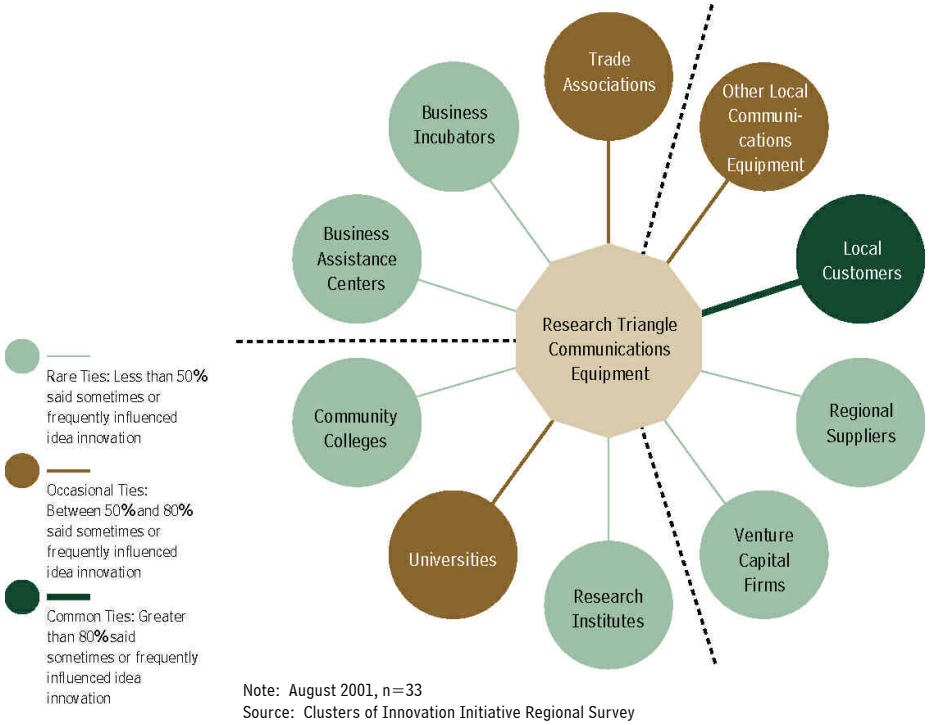
Institutions for Collaboration. The communications equipment cluster in the Research Triangle took off partly in response to the presence of IBM, Nortel Networks, and Cisco. Yet, with the exception of internal research and development departments within these multinationals, there are only a handful of institutions for collaboration serving the communications equipment cluster; two of these being the North Carolina Electronics and Information Technologies Association and, to a lesser extent, the more research-oriented the Center for Advanced Computing and Communication mentioned previously.

The North Carolina Electronics and Information Technologies Association is a non-profit organization established to promote and strengthen the electronics, telecommunications, software, Internet, and related service industries in North Carolina through increased public awareness, and to provide a forum to learn, educate, communicate, promote, network, and implement actions. Several interviewees cited the North Carolina Electronics and Information Technologies Association, with more than 1,200 members representing over 300 companies, as being very helpful for start-ups, especially in the communications equipment cluster.

The North Carolina Electronics and Information Technologies Association's strength as an established institution for collaboration is apparent in our survey results. Survey respondents were asked how frequently they interacted with other members of the cluster at the idea generation, product development, and commercialization stages of the innovation process. (See Exhibit 73). In the Research Triangle, communication firms are less likely to use partners to jointly develop or commercialize an idea than they are to generate new ideas. Less than 23% of firms say that they frequently used outside partners in their

commercialization processes, while 68.8% say they commonly look outside their firm for new ideas. Interview respondents in the communications equipment cluster mentioned that they are spurred to develop new product ideas by the competitive advances or technological developments of other cluster firms, most specifically Cisco and Nortel Networks.

Exhibit 73: Strengths of Linkages, Communications Cluster, Research Triangle



Note: August 2001, n=33
Source: Clusters of Innovation Initiative Regional Survey

CONCLUSION

The Research Triangle's communications equipment 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 run companies. Third, important though these connections have been, they are still developing and the cluster's performance reflects this fact. The communications equipment cluster is less well connected with basic researchers at the University of North Carolina-Chapel Hill, North Carolina State University and Duke University than is the pharmaceutical / biotechnology cluster, and the communications equipment cluster does not perform as well in terms of innovation output measures. Fourth, except for the North Carolina Information Highway, sophisticated local demand is not present. Fifth, the cluster's development demonstrates the need for sustained commitment; local leaders began attracting large communications equipment companies in the 1960s, but did not see major economic benefits from this until the 1980s. The communications equipment cluster did not emerge strongly until the 1990s. Sixth, anchor firms like IBM, Nortel Networks, and Cisco were important, but it has not been enough to generate a major locally owned communications equipment company.

OTHER RESEARCH TRIANGLE CLUSTERS: BRIEF CASE STUDIES OF THE TEXTILES, CHEMICALS, AND PLASTICS CLUSTERS

The chemicals, textiles, and plastics clusters represent a much smaller, but equally telling story of the Research Triangle economy. Whether it is the legacy inherited by the textiles cluster, or the more recent bonds between the chemicals, plastics (and pharmaceutical) clusters, these small (under 6,000 employees in each as an MSA, and under 17,000 in each as an EA) clusters represent important suppliers of specialized inputs, related industries, and various related industry organizations, educational institutions, and government agencies. They can also say a lot about how under-represented clusters tend to stack up against the bigger, more robust pharmaceutical / biotechnology and communications equipment clusters.

Development of the Research Triangle's Textiles, Chemicals, and Plastics Clusters

The history of North Carolina is inextricably tied to the development of the textiles, chemicals, and plastics clusters. Perhaps it can be traced back to several individuals, including Dr. Bartlett Durham's for whom the city of Durham is named and whose 1849 land grant led to the region's major railroad station, and Erwin Mills, who established the Erwin Cotton Mills — the world's first mill to produce denim. In those days, the use of chemicals in the textile industry became more and more commonplace. Eventually these chemical processes, which came to include the use of dyestuffs and dye intermediates, developed enough of a critical mass to employ a good number of the region's citizens.

For example, at the turn of the century, Raleigh, with a population of 28,000, began to see the textile industry take root. In 1899, a number of mills called Raleigh home, including Caraleigh Cotton Mill which employed 150 men, operated 8,528 spindles and 332 looms, and produced 1,000 yards of dress gingham a week. There were others, including the Raleigh Cotton Mill, the Pilot Mill, and the Neuse River Mill. But a couple of decades passed before these would rival the mills in the Northeast. In fact, it would not be until the 1920s that the North Carolina textile industry began to produce more than the New England mills.[113]

From the 1920s to the 1960s, the Research Triangle region began to specialize in the production of various fiber processes, including cotton cloth and bags, hosiery, muslin sheets, sheets, pillowcases, chambray and plaid cloth, ginghams, worsteds for suits, dresses, and auto fabric. From the 1960s to the present, the textiles cluster in the Research Triangle began to shift to more value-added products, such as polyester yarn, and women and men's apparel.[114] As a result, the textiles, chemicals, and plastics clusters became more and more linked to each other by way of the end products they provided customers and each other. Major textile companies such as Beaunit and Hercules, and diversified chemical firms such as Chemstrand, built R&D facilities in the Research Triangle Park's "first wave." The American Association of Textile Chemists and Colorists, which established its headquarters in the park in 1964, is the surviving representative of the chemical-textiles mix. But it also is distinguished as the first such trade association to call the Research Triangle Park home. Facilities built by the textiles giants, over the course of economic and scientific change, were taken over by new industries to follow, and the three clusters decreased their share of the regional economy. Yet, even in their diminished size, they remain highly specialized and innovative clusters, providing excellent linkages to other clusters, mainly pharmaceutical, world-class scientific and technical know-how, and high patent rates and average wages.

RECENT ECONOMIC PERFORMANCE

Employment. Textiles remains an important cluster within North Carolina, but less so within the Research Triangle. Out of the top 20 MSAs for the textiles cluster in 1999, no less than four MSAs are in North Carolina, with the largest being Charlotte-Gastonia-Rock-Hill, North Carolina, Greensboro-Winston-Salem-High Point, North Carolina, Hickory-Morganton-Lenoir, and the Research Triangle (15th largest MSA and ninth largest as an EA). The largest clusters are in Greenville-Spartanburg-Anderson, South Carolina with an employment of 47,764 as an EA, Augusta-Aiken, Georgia-South Carolina with an employment of 27,059 as an EA, and Atlanta, Georgia with an employment 78,777 as an EA. The Research Triangle MSA's employment of on 5,363 in the textiles cluster is dwarfed by the other much larger MSAs — though this is less apparent when the EA's employment of 16,931 is taken into account. Also, the region's textiles EA growth rate shrank over the 1990 to 1999 period by 4.1%, echoing an overall national trend in which only three of the top 20 EAs registered minimally positive growth in the cluster.

The chemicals cluster has a similar employment environment. 1999 total employment in the Research Triangle's EA chemical cluster was 13,774, making the region the 22nd largest in the nation. This employment is substantially less than the leading chemicals cluster of Houston, Chicago, and New York. Nevertheless, the Research Triangle grew its share of national employment from 0.8% in 1990 to 1.2% in 1999, registering a 4.3% growth rate between 1990 and 1999, while more than half of the 20 largest EAs decreased their share of national employment and growth rates during the same period.

The plastics cluster employed 6,917 in 1999 in the Research Triangle EA, making it the 58th largest plastics cluster in the nation. These employment numbers were far less than Chicago, Houston, and Newark, but the Research Triangle EA's growth rate was 6.6%, the fastest if included among the 20 largest EAs. Given the small size of the cluster, the Research Triangle EA had only 0.5% share of the national employment in 1999.

Average Wages. The Research Triangle EA's average wages in the textiles cluster were somewhat lower than both the pharmaceutical / biotechnology and communications equipment cluster, but the region had the 14th highest average wages at $28,540. The highest wages in the textiles cluster are found in Chicago and Boston. Over the 1990 to 1999 period, growth rates for the textiles cluster in the Research Triangle EA were not available.

Average wages in the chemicals cluster in the Research Triangle were $53,601, fifth highest if included among the 20 largest EAs for the cluster. As an index of the national average wage, the Research Triangle EA chemicals cluster was 6.7% higher than the national average in 1999.

The plastics cluster in the Research Triangle EA had an average wage of $27,497 in 1999, 25% below the national index for 1999.

Patent Registration. There were 7 patents registered in the Research Triangle EA's textiles cluster in 1998, making it the tenth highest total among all EAs. This amount was substantially less than the benchmark EAs of Boston and Chicago. Nevertheless, given the small size of the Research Triangle EA's textiles cluster, the region had 0.7% share of the total national patents for the cluster. The region also enjoyed an annual growth rate of 4.2% in its textiles cluster, ninth highest among the twenty largest textiles clusters. At 0.36 patents per 1000 employees in 1998, ninth highest among the twenty largest EAs, the Research Triangle lagged other regions, including Chicago and Philadelphia.

With 142 patents granted in the Research Triangle EA's chemicals cluster in 1998 the region did well given its small size. This is more remarkable given that there were only 45 patents registered in 1990, giving the Research Triangle EA a growth rate of 13.7% or seventh highest among the 20 largest EAs. On a patent per employee basis, the Research Triangle EA also did well, with 10.37 patents per 1000 employees, the tenth highest if the region were to be included among the 20 largest EAs for the chemicals cluster.

The Research Triangle EA had 57 patents registered in 1998 in the plastics cluster, providing the region a 0.7% share of the total national patents for that year. This is a substantial increase from only 23 patents issued for the MSA in 1990, giving the Research Triangle EA a growth rate of 10.9%, the highest growth rate among the 20 largest plastics cluster EAs. The region nevertheless still trails such benchmark regions as Chicago and Boston. On a patent per employee basis, however, the Research Triangle EA performs well, with 10.4 patents per employee in 1998, versus only 4.7 patents per employee in 1990.

CLUSTER INNOVATIVE CAPACITY

Specialized Research Centers. The North Carolina State University has perhaps the best school of textiles in the world with its Textile Protection and Comfort Research Center. The Center serves as a nucleus of activity for coordinating and managing diverse research projects in the area of combined textile comfort and protection. The Textile Comfort labs include the complete Kawabata system for fabric hand evaluation, state-of-the-art sweating skin models, a full-range walk-in environmental chamber capable of rapidly cycling through common or extreme temperature and humidity conditions, plus facilities and exercise equipment required for human textile comfort response protocols.

The Textile Protection and Comfort Research Center features a thermal manikin called Coppelius, which is housed in the environmental chamber. Coppelius is one of only two "sweating manikins" in the world and allows the Textile Protection and Comfort Research Center to make objective, safe and precise predictions of human comfort response and heat stress under diverse climatic and work load conditions. The Textile Protection and Comfort Research Center also has PyroMan, a fully instrumented, life-size manikin capable of evaluating the performance of thermal protective clothing against fire exposure. The potential tissue burn damage to a wearer when exposed to a realistic simulation of a flash fire condition can be predicted. PyroMan is one of only a few such manikins in the world, and the only one of its kind in a university research setting in the United States. In addition, the Textile Technology program at North Carolina State University has the greatest number of students of any textile technology curriculum in the United States.

Also at North Carolina State University is the Nonwovens Cooperative Research Center, established as a State/Industry-University Cooperative Research Center in 1991 as a result of a grant from the National Science Foundation. The National Science Foundation grant was matched by the State of North Carolina and grants from the nonwovens industry. The Nonwovens Cooperative Research Center serves the nonwovens industry through fundamental and applied research in the technologies of the industry and an active program of technology transfer.

Finally, as one of its specialized areas of research, the Research Triangle Institute has been conducting research in analytical chemistry for more than 25 years. The Analytical and Chemical Sciences chemists have been developing and applying sophisticated analytical techniques to measure trace levels of organic

and inorganic chemicals in a variety of matrices from biomedical, environmental, manufacturing, and energy processes. With the increase in local and international demand for research in this field, the Research Triangle Institute grew a second facility for polymer chemistry research, the Camille Dreyfus Laboratory.

Specialized Educational Institutions and Talent Pool. The Department of Chemical Engineering at North Carolina State University is rapidly developing into one of the leading departments in the nation. Established in 1924, it has 20 dedicated and enthusiastic faculty who supervise 85 full-time graduate students, 75% of whom are PhD candidates. The Department is routinely among the top chemical engineering departments in research expenditures in the country. In fact, in 1996 the National Research Council ranked North Carolina State University's Graduate Chemical Engineering program first in the Southeast.

The Polymer and Textile Chemistry program at North Carolina State University is the largest of its type in the North America and Europe. Graduates of this program readily find employment in the research, manufacturing, and marketing segments of the fiber and textile industry. Other graduates go on to advanced studies in business and the physical sciences, including fiber and polymer science.

Context for Firm Strategy and Rivalry. The German chemical giant BASF also has major operations in the area and has consistently consolidated operations from other regions in the Research Triangle. For example, in 1996 its Sandoz Agro Inc. unit, previously headquartered in the Chicago suburb of Des Plaines, Illinois, was combined with BASF Corp.'s Agricultural Products Group, which is headquartered in Research Triangle Park.

Established in 1927 by founder Henry Reichhold, Reichhold, Inc. provides advanced polymers, adhesives and polymer systems. Reichhold is based in Research Triangle Park and is a subsidiary of Dainippon Ink and Chemical of Tokyo, Japan. Also in the Research Triangle Park is Eastman Chemical Co. of Kingsport, Tennessee, the largest supplier of polyester plastics for packaging in the world.

Institutions for Collaboration. The American Association of Textile Chemists and Colorists, along with IBM, is the only original tenant at the Research Triangle Park that is still in the Park. The American Association of Textile Chemists and Colorists develops test methods that examine the fabrics used in clothing, furniture, and other products for properties, such as stretching, fading, care properties and performance. The association has approximately 7,000 members worldwide. The American Association of Textile Chemists and Colorists eventually settled on the Research Triangle Park largely for reasons unrelated to the Park's "vision." The location was chosen for its proximity to major textile centers, many of which were located within 150 miles, the low cost of office space, and the quality of life. The process of choosing a new site emerged into a north versus south battle, with members north of the Mason-Dixon line insisting the organization would alienate them by moving to the south.[115]

The chemicals cluster is also well represented in the Research Triangle Park by way of hosting the International Union of Pure and Applied Chemistry. The International Union of Pure and Applied Chemistry serves a worldwide membership and promotes standardization of nomenclature, terminology and methods in the chemical science field. The International Union of Pure and Applied Chemistry was formed in 1919 by chemists from industry and academia and is among the world authorities on chemical nomenclature, terminology, standardized methods for measurement, atomic weights, and many other critically evaluated data. The Union continues to sponsor major international meetings that range from specialized scientific symposia to international meetings. The International Union of Pure and Applied Chemistry settled in the Research Triangle Park in 1997 when the organization decided to move its head-

quarters out of Oxford, England. The International Union of Pure and Applied Chemistry considered sites in Paris and Frankfurt before settling on the Research Triangle Park. According to the association, cost estimates indicated it would be less expensive to locate there than in Frankfurt or Paris. In addition, the Research Triangle Park was a good location because of the universities and nearby academic environment, as well as the large presence of scientists in the community, the excellent quality of life, and the extensive resources available in both academia and private laboratories.

Also at the Research Triangle Park is the Chemical Industry Institute of Toxicology, which serves the chemical industry as an independent laboratory. Thirty-six chemical companies provide funding that drives independent research to benefit the entire industry, so that the organization acts more like a trade association for chemical companies rather than an organization with individual members. A common theme among all these organizations is that they work closely with the local universities.[116]

CONCLUSION

The Research Triangle's textiles, chemicals, and plastics clusters are instructive cases for several reasons. First, they show that formerly large clusters can be revived in ways that lead to innovation and to well-paying jobs in the cluster. Second, even though their employment numbers are small, strengths in these smaller clusters lead to strengths in the general economy by providing opportunities at the intersection of clusters. Third, important though these connections have been, they are still developing and the clusters' performance reflects this fact. The chemicals and plastics clusters are less well connected with basic researchers at the University of North Carolina-Chapel Hill, North Carolina State University, and Duke University than is the pharmaceutical / biotechnology cluster, and as a result do not perform as well in terms of innovation output measures. Fourth, a more comprehensive approach, in the form of an Economic Area analysis rather than a Metropolitan Statistical Area footprint, should be made with these three clusters. As a percentage of national employment, the Research Triangle EA achieves much higher rankings than those of the Research Triangle MSA – for textiles it is eight largest as an EA (versus 24th largest as an MSA); for plastics it is 46th largest as an EA (versus 91st largest as an MSA); and, for chemicals it is 95th largest as an EA (versus 128th largest as an MSA). Fifth, the clusters' development demonstrates the need for sustained commitment; local leaders downplay the importance of the textiles cluster in particular, without seeing the potential economic benefits of combining expertise across clusters. Sixth, the lack of anchor firms is an important reason why these clusters have not broken out of the pack and developed to the size of the other leading clusters in the region.

SUSTAINING COMPETITIVE ADVANTAGE: LESSONS, CHALLENGES, AND OPPORTUNITIES 5

ACCOMPLISHMENTS

The Research Triangle leaders have accomplished much in the development of the regional economy over the last four decades. Beginning in 1958, local government attracted both key government agencies and large multinational corporations that spawned numerous business clusters (e.g., information technology, communications equipment, and pharmaceutical / biotechnology). In the 1970s and 1980s, government and industry attracted bioscience research centers that produced high innovation output and helped develop additional clusters. The leaders of these research centers encouraged resident scientists and engineers to collaborate with industry and, despite initial resistance, were ultimately successful. Finally, university activism produced the Centennial Campus and model institutions for collaboration that facilitated the flow of research and ideas from the university.

Assets

These accomplishments have left the Research Triangle with a number of assets that have been critical to the economic development of the region. Prominent among these assets are the Research Triangle Park and specialized research centers across different clusters. Without these assets, the region would have not enjoyed the kind of success evident in the last four decades. The Research Triangle Park established the foundation for the region to gain positions in fast-growing industry clusters, including the information technology, communications equipment, pharmaceutical / biotechnology clusters. The region also enjoys a competitive cost position versus other technology centers with which it competes, including Boston and San Jose, both of which are higher-cost areas to operate in. The presence of world-class universities and community colleges is enhanced by the collaboration that occurs between these training institutions and business. Out of this collaboration comes good workforce training infrastructure. Other assets enjoyed by the region include the high levels of federal and state R&D investments, some of which are among the highest in the nation on a per capita basis. The combination of these assets has produced a good standard of living and relatively low unemployment that, in turn, has led to a high quality of life for the residents of the Research Triangle region. The result is strong regional innovation capacity, as well as strong innovative capacity for numerous clusters. Exhibit 74 on the following page summarizes the innovative capacity of the Research Triangle region.

Exhibit 74: Regional Innovative Capacity Summary, Research Triangle

Elements of Regional Innovation Environment	Assets	Challenges
Basic and Specialized Factor Inputs	■ High levels of investment in basic research ■ Many research institutes in a variety of sectors ■ High quality of life ■ Good higher education ■ Large number of scientists and engineers in the workforce	■ Public K-12 educational system ■ Inadequate physical infrastructure ■ Lack of corporate headquarters ■ Average Wages
Government Policy	■ High level of federal R&D funding ■ High level of state support for UNC and NCSU	■ Lack of updated vision for the region ■ Weak collaboration among communities ■ Historical focus on a limited array of clusters
Quality of Linkages	■ Strong informal networks ■ High quality university-business institution for collaboration (NCBC, MCNC, DUMC, RTI)	■ Low collaboration within many clusters ■ Limited contribution by suppliers in the innovation process ■ Need for improvement in the technology commercialization structure
Attitudes Toward Business	■ Entrepreneurial attitudes in academia	■ Signs of a shift back towards an ivory tower mentality

Source: Clusters of Innovation Initiative Regional Survey™ and Interviews

Lessons

The Research Triangle's accomplishments, and the process by which the local residents have encouraged the development of their economy, offer numerous lessons for how other regions can emulate its success.

Universities and specialized research centers were the driving force of innovation in the region. North Carolina State University, the University of North Carolina-Chapel Hill, and Duke University in Durham formed the pillars of the region's knowledge-based economy by providing world-class research facilities as well as a critical mass of scientists, researchers, and technicians. Their research capabilities helped in the development of a large number of clusters in the region. These include not only biotechnology / pharmaceutical and communications equipment, but also plastics, chemicals, fibers, medical devices, analytical instruments, and education and knowledge creation. These universities formed the basis for the Research Triangle Park.

Diversity of research institutions creates healthy competition and speeds progress. Such research institutions as the Research Triangle Institute, the Duke University Medical Center, the Center for Advanced Computing and Communication, the National Institute of Environmental Health Sciences, and the United States Environmental Protection Agency enable companies to choose from a diverse set of models of how research institutions interact with companies in the region. Competition among local research institutes also stimulated more innovative research.

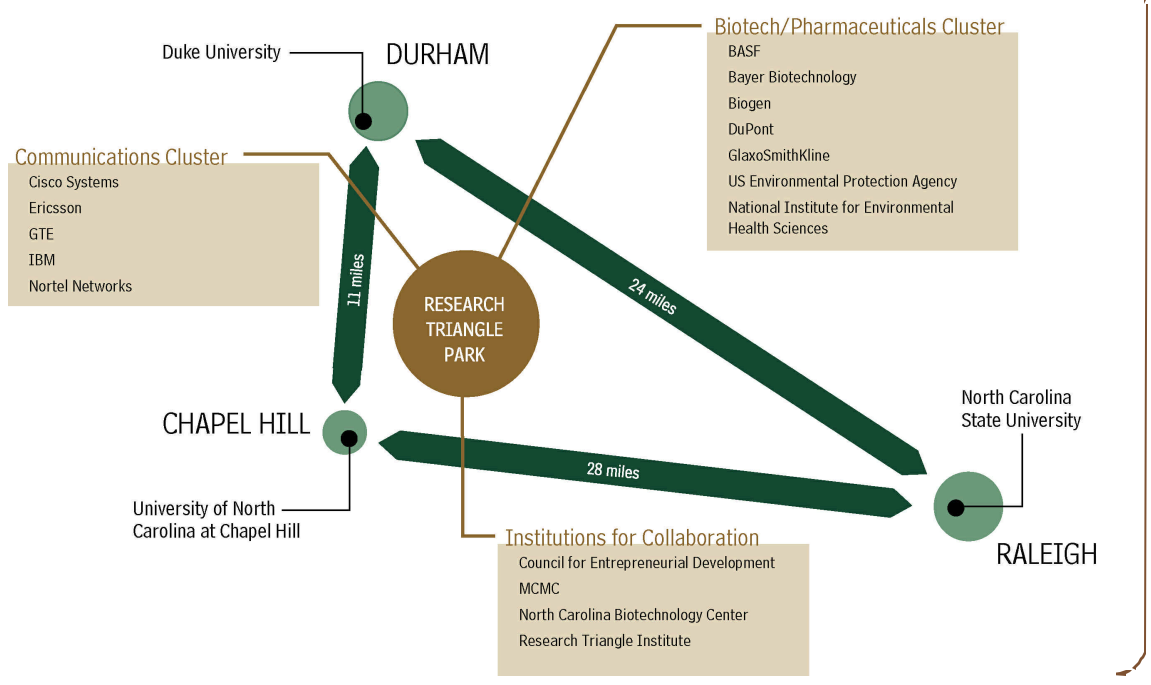
Specialized talent and training are more important than abundant, low-wage labor. The University of North Carolina-Chapel Hill, North Carolina State University, Duke University, local private universities, and the region's community colleges offer a variety of general courses and specialized programs at the undergraduate, graduate, and continuing education levels. In recent years, the Research Triangle has improved its academic and training infrastructure to support specialized research in commu -

nications equipment related fields. Executives who were surveyed or interviewed indicated that their companies located to the region in part due to the highly trained and abundant local talent.

Proximity fosters productivity and innovation. Leaders from the Research Triangle region's universities, business, and government cooperated to create what has become one of the most successful planned science parks in the world, the Research Triangle Park. The 7,000-acre "Triangle" is defined by three universities located less than 30 miles apart: North Carolina State University, the University of North Carolina-Chapel Hill, and Duke University in Durham. Their research capabilities complement other important research institutions located inside the Park, including the North Carolina Biotechnology Center, the Microelectronics Center of North Carolina, the United States Environmental Protection Agency, the National Institute of Environmental Health Sciences, and the Research Triangle Institute.

Over time these geographically proximate educational and research institutions have been able to undertake major joint efforts, such as the Triangle Universities Center for Advanced Studies Inc., and the shared nuclear laboratory at Duke University, research luxuries that no school could justify on its own. Uncharacteristically close cooperation between these three geographically proximate institutions helps the region win more federal research dollars than would otherwise be the case. But the "if we will build it, they will come" story is only half of the reason for the Research Triangle Park's success. There is an equally important private-sector presence that helps explain the region's ability to compete. The growing presence of research-oriented companies has promoted, often consciously and deliberately, the development of needed supporting and institutions for collaboration (see Exhibit 75 below).

Exhibit 75: Research Triangle Park, North Carolina



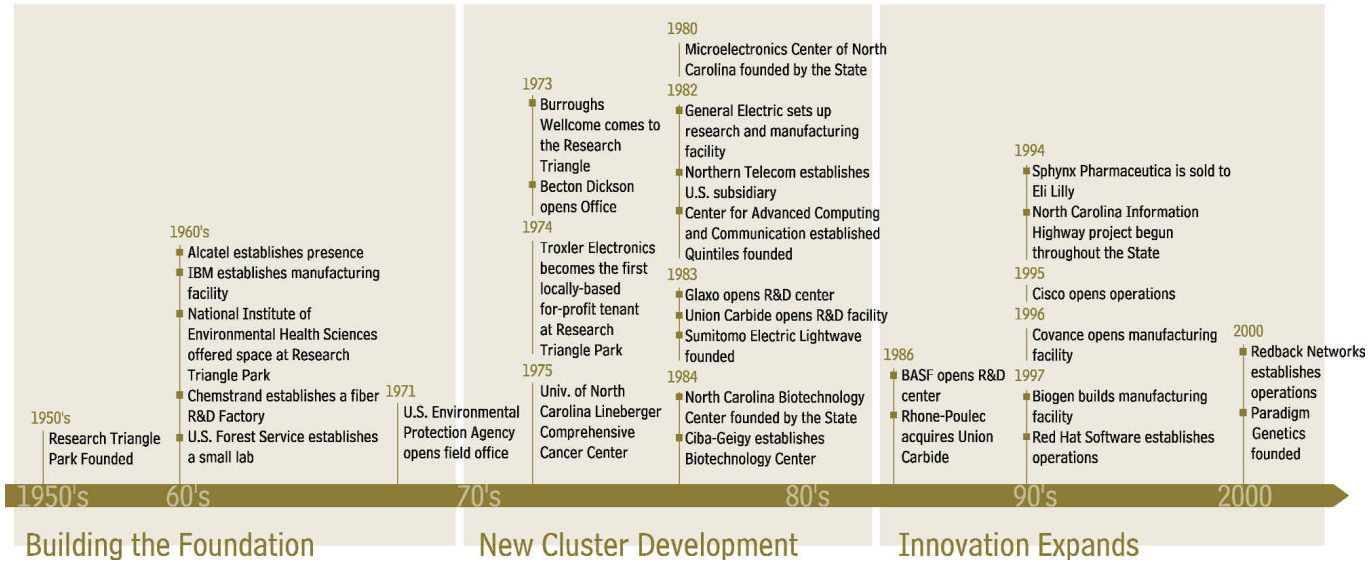
Source: Research Triangle Foundation

Institutions for collaboration lead to innovation and play an important role in building the regional economy. The base assets for the communications equipment and pharmaceutical / biotechnology clusters existed in the Research Triangle by the 1970s, but the clusters did not emerge strongly until the 1980s to1990s. One reason for the lag was that the region lacked people with business experience, and risk capital. The Center for Entrepreneurship Development, the North Carolina Biotechnology Center, the Microelectronics Center of North Carolina, and the Centennial Campus were subsequently founded to focus on bridging both of these gaps. Local clusters began to show strength shortly thereafter.

Strong leadership is a necessary part of the region's successful economic development strategy. The leadership of a few dedicated people can change the trajectory of economic development. The region's leaders not only proved critical for the development of key institutions, but also provided a high degree of vision and cohesion in critical moments in the region's history. Research Triangle Park demonstrated the fundamental role of leadership in building an innovative economy. All governors since have been instrumental in the formation and development of the Research Triangle Park as well as the local educational institutions.

B**uilding strong regional economies takes decades**. There are many steps in building a regional economy—developing inherited assets, creating new assets, linking companies to these assets, attracting outside companies—and this process takes time. It took 20 years to build a large corporate R&D presence in the Research Triangle, and another 20 to see significant economic consequences flow from it. The Research Triangle Institute opened in 1958, but the biotechnology / pharmaceutical 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 (see Exhibit 76 below).

Exhibit 76: Four Decades of Development in the Research Triangle Region



Government can have a significant influence on the business environment, both positively and negatively. In 1958, with the economy of central North Carolina still dependent on maturing industries such as tobacco and textiles, the state's government and business leaders, including North Carolina Governor Luther Hodges, set out to foster economic development through far-sighted investments in universities, research centers, and infrastructure. Challenged by discontinuities, cluster-generating companies and crusading individuals (e.g., former Governors since Hodges) forged inter-relationships, promoted the development of supportive institutions (e.g., the Research Triangle Foundation), and pioneered the growth of the present clusters. Collaboration thus brought the government, bioscience research centers, the local universities, the United States Environmental Protection Agency, and the National Institute of Environmental Health Sciences to the region. The success of the Research Triangle region demonstrates that public and private collaboration is necessary, not either alone.

Higher levels of innovation output lead to higher levels of prosperity. In the late 1950s, North Carolina was among the states with lowest in the country in terms of wage and employment levels. Despite having three strong local universities, educational levels were also quite low because university graduates left the area after receiving their degrees. Textiles and tobacco dominated the economy, and Research Triangle was on a trajectory of long-term economic stagnation. Then a group of business, academic, and government leaders worked together to create and develop Research Triangle Park. The Park offered companies easy access to physical infrastructure, human resources, and knowledge assets, and research-oriented companies began to locate in the region. Four decades later, Research Triangle has a growing, prosperous economy that is clearly the result of the successful innovation. In the 1950s, Research Triangle had an abundance of low-cost labor, but dim economic prospects. Innovation changed that.

Challenges

The Research Triangle economy has performed well over the last decade and the efforts of local leaders provide numerous lessons for other regions to emulate. Nevertheless, the region 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. The Research Triangle is no longer a "pleasant small town." Explosive growth has placed a burden on much of the region's infrastructure. The consequences of success threaten to undermine several of the Research Triangle'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 the Research Triangle is to develop an economy that competes with the best in the world.

Physical infrastructure is inadequate. The Research Triangle needs to upgrade aspects of its physical infrastructure. Most critical will be increasing its roads and its air transport capabilities, including number of key destinations and frequency of flights. This issue consistently emerged in both surveys and interviews as a high priority problem. The region needs to increase its flight destination network if it is to meet the needs of sophisticated local industries. On the horizon is a regional light rail under the auspices of Triangle Transit Authority, zoning changes that would encourage more housing near corporate parks and a variety of road improvements. Even with these initiatives in motion, the region's leaders will need to focus more efforts at solving this key challenge. The Research Triangle, and North Carolina, must also

guarantee its residents reliable water supplies and a better system of local roads. Rapid economic and population growth confront the Research Triangle with a host of physical infrastructure issues. Resolving these issues has proven difficult in the past, and yet failure to solve them will result in a significant degradation of the local quality of life, one of the Research Triangle's key assets over the years.

K-12 education is lagging. Although the Research Triangle's high-quality higher education has been a key source of success in the past, it is also clear that the region's K-12 educational system is lagging that of other regions. Executives who were surveyed or interviewed indicated this lag as one of the most important challenges to the region, especially in relation to the recruitment of top management personnel, most of which had families with children in search of excellent schooling. The Research Triangle should continue to upgrade its K-12 education system. Our assessment of the quality of basic education is that the Research Triangle is at, or slightly above, the national average. Average is probably not good enough for a *knowledge*-intensive economy like the Research Triangle's.

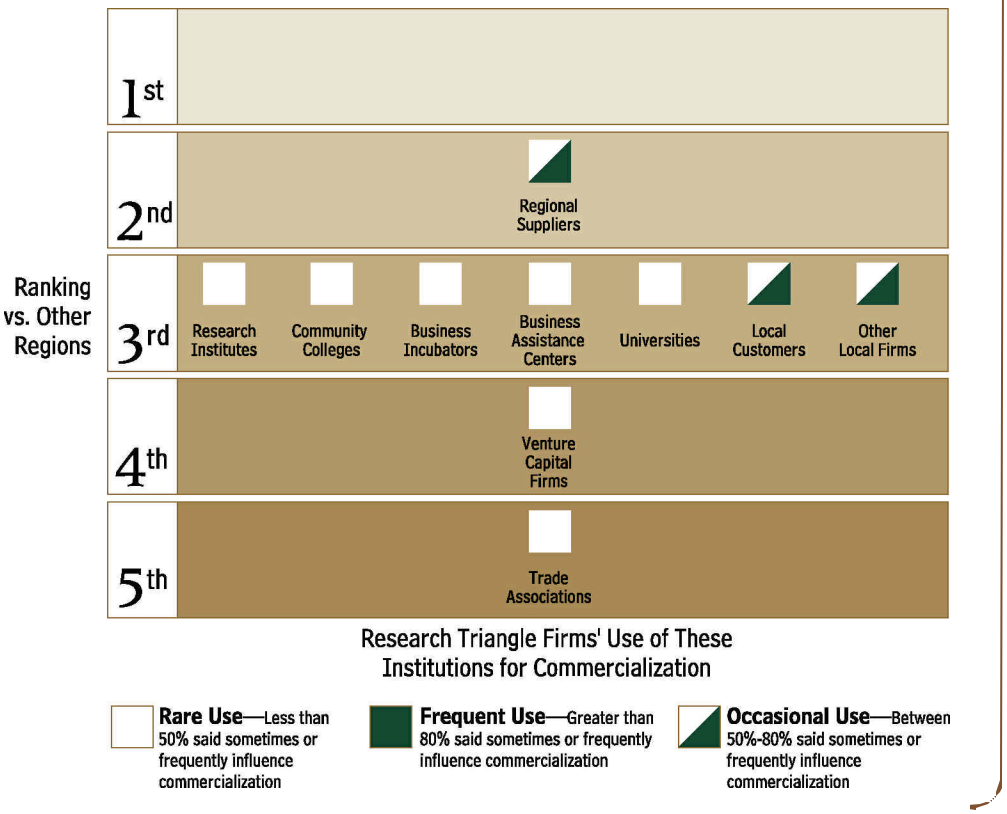
Need for improvements in the technology commercialization structure. Commercialization of basic research is a difficult and important ingredient for generating entrepreneurship. The Research Triangle region has high levels of R&D investments and numerous specialized research centers, but still lags in terms of innovation output because knowledge is not transferred to companies as effectively as it could be. The Research Triangle's leaders have been successful in attracting research institutions to the region — more than 10 major specialized research centers are located in the Research Triangle. The Research Triangle consistently receives more than six to seven times the national average of R&D investment per worker as a result of having these specialized research centers. Yet surveys indicate that institutions for collaboration and research centers in the Research Triangle are not helping the region's firms as much as they could.

In each of the five regions we surveyed, we asked executives how often they used various institutions in the commercialization process. The results indicate that companies in the Research Triangle area use these institutions and centers relatively infrequently. Of the five regions studied, Research Triangle ranks third to fifth in all but one of the influences on commercialization of technology (see Exhibit 77 on the following page). While having improved from previous years, several interviewees indicated that technology transfer was still an area where much more could be done. This is especially true in regards to start-ups in the pharmaceutical / biotechnology cluster.

A point related to this lack of commercialization capabilities involves the expansion of manufacturing operations outside and near the Research Triangle Park to complement the research that occurs within the Park. Such efforts will help companies in the Research Triangle region compete internationally. The Research Triangle has low per capita exports and export growth rates. These export numbers do not include high and rising sales in competitive markets abroad. 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.

Historical focus on a limited array of clusters. Research Triangle should build strength in a wider array of clusters. Diversification away from a limited array of clusters is critical, given the region's over-dependence on a few, albeit strong, clusters. A downturn in one, as is currently the case in the communications equipment cluster, will lead to widespread effects on other clusters, including business services. Because it takes time to build these assets, clusters in the Research Triangle should begin doing so now. An expanded focus on such new and emerging clusters as medical devices and analytical

Exhibit 77: Strength of Linkages, Research Triangle Region, Commercialization of Technology



Note: August 2001, n=116
Source: Clusters of Innovation Initiative Regional Survey

instruments should be undertaken. Other smaller clusters should also be integrated into this updated strategy. These clusters include textiles, plastics, and chemicals. Even in their diminished size, they remain highly specialized and innovative clusters, providing excellent linkages to other clusters, mainly pharmaceutical, world-class scientific and technical know-how, and high patent rates and average wages.

Lack of large corporate headquarters in the region. While it is true that several successful companies have spun out of GlaxoSmithKline, IBM, Cisco, and Nortel, there is currently no locally owned major pharmaceutical / biotechnology or communications equipment company. In fact, the only Fortune 500 company based in the Research Triangle region is Progress Energy (number 459). All the other North Carolina firms on that list are based in Charlotte (with six companies on the list), Winston-Salem (with three companies), or Greensboro/Wilkesboro (with one each).

Also important is the fact that out of North Carolina's top 20 largest private sector employers, only 2 companies have operations in the Research Triangle (IBM and Nortel, number 4 and number 20 respectively). While Progress Energy, Quintiles, and SAS have local headquarters in the region and are very involved in their communities, overall community sponsorship and leadership efforts suffer as a result of the lack of large corporate headquarters.

Weak collaboration among communities. The Research Triangle region has been the 12th fastest growing MSA in the United States over the last decade. Growth has spurred the increase in the political independence of local jurisdictions that used go along with more regional economic development plans. The former vision of the region as a growing center of research excellence (built around Research Triangle Park and the metropolitan area) has reached its limits in terms of being able to generate consensus behind regional economic development programs. Collaboration among local leaders and institutions for collaboration in the area is more difficult today. This has made it hard to push through economic development strategies that benefit all jurisdictions and not just one.

The Research Triangle region's governments and communities receive decidedly mixed reviews in our surveys. The mixed reviews are directed at both the substance of government's decisions and the processes by which those decisions are reached: "Political leaders (in the form of individuals, mainly the Governor) have traditionally been very helpful and active, whereas the state (as an amalgamation of individuals) has been ineffectual uninvolved and irrelevant;" "Local government is not very effective. It's not the red tape. It's just that there is no vision;" "There is no regional consensus and no state strategy in identifying or funding emerging technologies;" "The old leadership in the region was really visionary in their selection of certain technologies on which to focus their efforts. Does the region have that kind of vision for the next ten or twenty years?"[117]

Low collaboration within many clusters. Innovation comes from the sharing of ideas and information across firms and organizations in a cluster. Surveys indicate, however, that companies in the studied clusters have relatively low levels of collaboration. Although the region has some effective cluster-specific institutions for collaboration surveys and interviews indicate that more are needed to help facilitate the flow of information and resources throughout clusters. Diverse groups (e.g., rival firms, related and supporting industries, universities and research centers, training institutions, government, and so forth) contribute to cluster strength, and their contribution is not automatic. The region needs more organizations dedicated to mobilizing these groups.

THE NEED FOR NEW DIRECTIONS

The Research Triangle has become a highly competitive and innovative region. Yet competition is dynamic, and to remain competitive, the Research Triangle must be dynamic as well. Our analysis identifies several themes by which the Research Triangle can transition from a young and growing economy to a mature and strongly performing economy. (See Exhibit 78 on the following page).

From the Research Triangle Park to a new strategy for the region. The original strategy of creating Research Triangle Park, and using the assets in local universities to help develop the regional economy has been a tremendous success. Rather than lose the region's most talented workers, the strategy helped retain them, and attract outsiders. Successful companies were recruited, and local companies started and enjoyed great success.

The success of this strategy, however, has created problems that cannot be solved by the current course. Growth is leading to more traffic, stressing the local school systems, increasing the cost of living; amenities that enabled the old strategy to succeed. Communities within the Research Triangle area, no longer galvanized by a common economic challenge, do not collaborate as well as they have in the past.

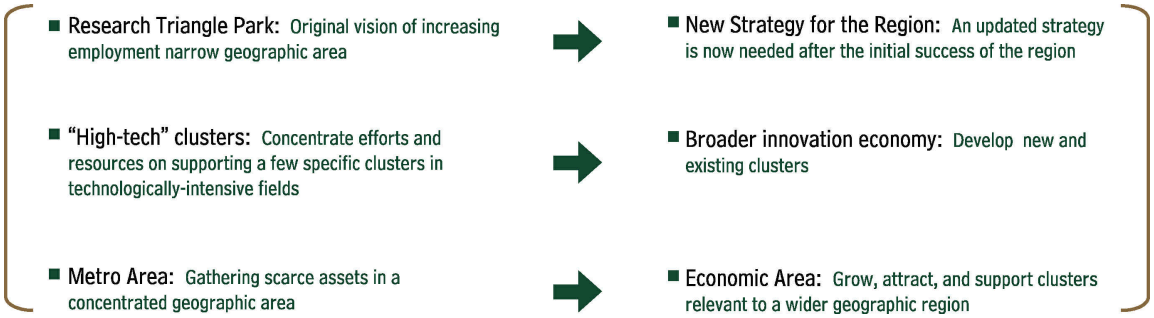
Prosperity is also narrowly focused in a few local clusters and in the metro area, which has led to some resentment in other communities. Interviewees report a sense of drift among the local leadership. A new economic strategy is needed to reenergize the community, increase collaboration, and solve ongoing challenges.

From "high-tech" clusters to broader innovation economy. Clusters in the Research Triangle such as pharmaceutical / biotechnology, information technology, and communications equipment have received considerable attention and support from universities, economic development organizations, and various levels of government, and have succeeded in part because they got that support. These "high-tech" clusters are not, however, the main employers in the region. Clusters such as business services, education and knowledge creation, heavy construction services distribution services, and financial services have created the most jobs in the region from 1990 to 1999. The next step in the Research Triangle's economic development is to support innovation across all clusters. These include those most closely aligned with these developed clusters, including: analytical instruments, medical devices, plastics, chemicals, and textiles.

From Metro Area to Economic Area. The Research Triangle leaders have focused on a narrow geographic area. The strategy of Research Triangle Park was to concentrate the scarce resources of local universities, and create a critical mass of institutions that would retain local workers and attract outside companies. The success of this strategy is very impressive.

Now, however, critical mass has been achieved, and indeed the concentration is creating problems (e.g., traffic, rising housing costs) that tend to undermine some of the historical strengths of the region. Moreover, areas of strength exist in a wider economic area. Relatively strong and growing clusters that exist in the economic area, but not the metro area, include tobacco; power transportation and distribution; prefabricated enclosures; construction materials; heavy machinery; processed food, building fixtures, equipment, and services, and agricultural products. A new strategy should focus on using the knowledge assets concentrated near Research Triangle Park to boost innovation in relatively strong clusters located across a wider geographic area.

Exhibit 78: Economic Vision for the Research Triangle, New Directions



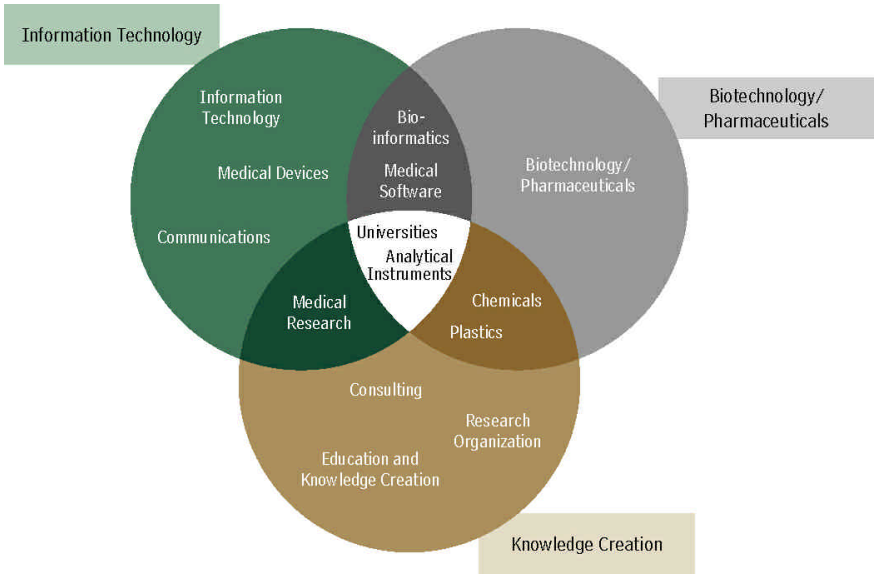
OPPORTUNITIES

In addition to confronting threats to historical assets, the Research Triangle faces opportunities that are under-realized. These include updating the original strategy behind the Research Triangle Park, establishing collaboration among a wide array of clusters, broadening the economy within many clusters and among communities, and attracting additional home bases to the region. Certainly local residents are aware of most these opportunities, and to some extent exploit some of them. However, based on our interviews, the issues receive less attention than they could and should.

Improve collaboration in the "high-tech" clusters. The Research Triangle has the opportunity to support and boost innovation across a large number of "high-tech" clusters. Many regions in the United States have only a few relatively concentrated "high-tech" clusters. The Research Triangle, however, has a large number of these clusters already present in the region. These include not only pharmaceutical / biotechnology and communications equipment, but also information technology and education and knowledge creation as well. Executives who were surveyed and interviewed indicated that these developed "high-tech" clusters should develop closer collaborative relationships given the potential for mutual gains. Some respondents indicated that these collaborative relationships have already begun in areas such as bio-informatics.

Create a strategy to upgrade a wider array of clusters. In addition to improving collaboration among these clusters, the region also needs to create a strategy to upgrade a wider array of clusters. These might include: analytical instruments, medical devices, plastics, chemicals, and textiles. Though high-tech clusters pay well, they are also relatively small. Supporting a wider array of clusters will boost innovation, productivity, and wages for a wider range of citizens.

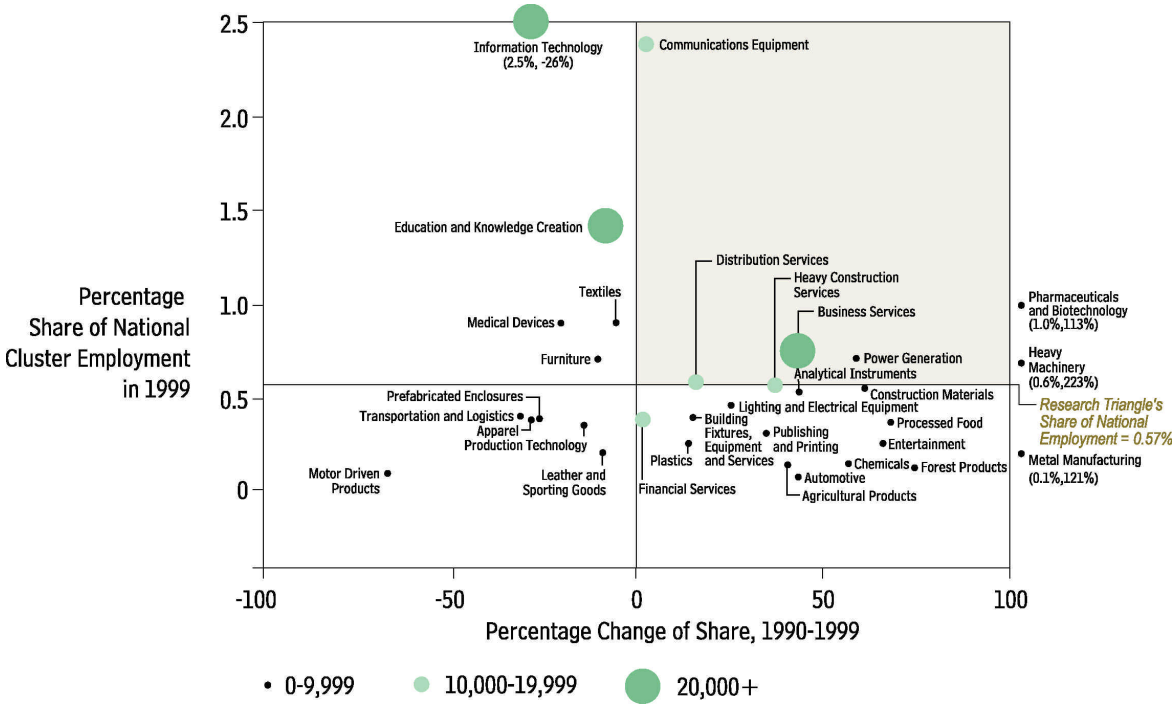
Exhibit 79: Opportunities at the Intersection of Clusters, Research Triangle Regional Economy



Develop opportunities at the intersection of clusters. There appear to be a number of under-exploited, crosscutting cluster opportunities in the region. Examples might be environmental sciences, biotechnology and information technology, telecommunications and medicine, and biotechnology and agribusiness. Some of the failure to address these horizontal issues may stem from weaknesses in existing connecting institutions. Substantial efforts at developing more collaborative relationships between clusters should also be explored. In the pharmaceutical / biotechnology cluster, more emphasis should be placed in a couple of areas in particular: bioinformatics, medical software, universities, analytical instruments, chemicals, and plastics. (See Exhibit 79 on previous page.)

Integrate the economy with the broader region. When devising economic development strategies, regions tend to focus on the immediate geographic area, usually a metropolitan statistical area. In some cases this is appropriate. In the case of the Research Triangle, however, a focus on the metro area neglects a wide range of assets that are readily accessible and part of the regional economy. The Research Triangle area, for example, has considerable assets in regions just outside the metro area. Exhibit 80 below shows the Research Triangle's Metro Area employment share and growth in share of the 41 traded clusters in the United States economy. The upper right quadrant represents clusters that have a disproportionate share of national employment in the Research Triangle and are growing their share. The Research Triangle has 34% of its MSA employment in six clusters (communications equipment, pharmaceuticals / biotechnology, distribution services, business services, power generation, heavy construction services) that have a relatively higher share of national employment and are growing in share of national employment.

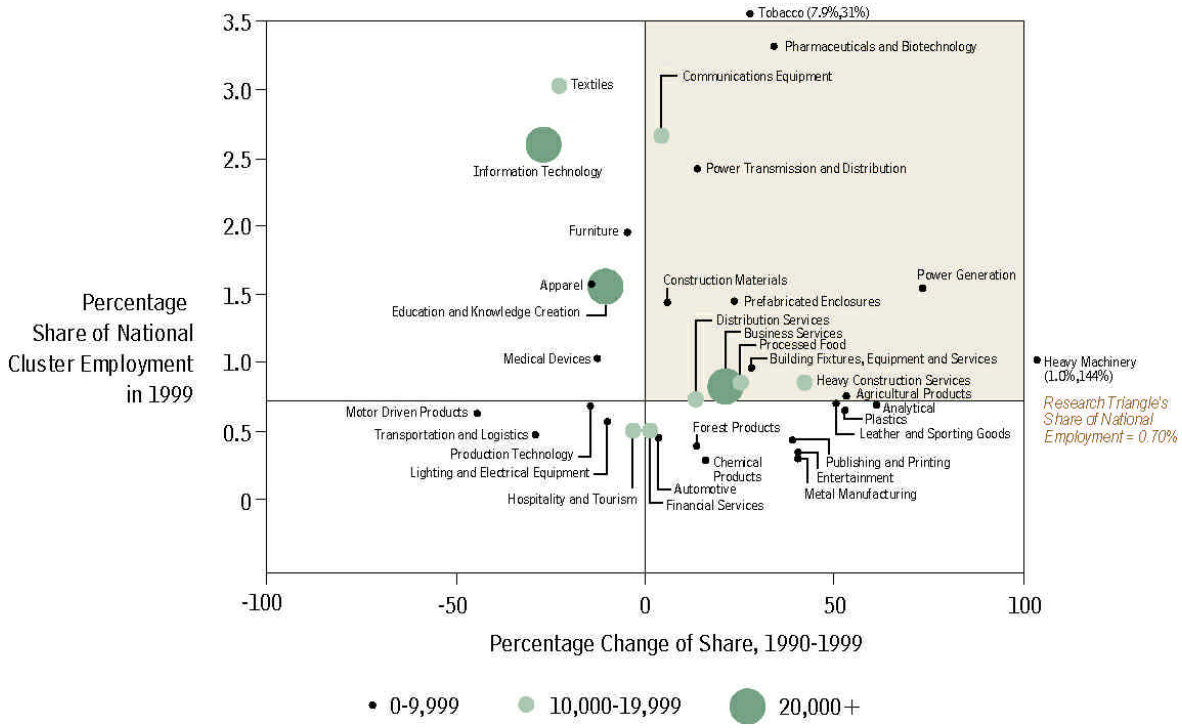
Exhibit 80: Specialization of the Research Triangle MSA, Narrow Cluster Definition



Note: (y-axis, x-axis)
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

Exhibit 81 below is the same graphic, but for the Research Triangle Economic Area. The region has 43% of its EA employment in 12 clusters that have a relatively higher share of national employment and are growing in share of national employment. These additional six clusters (power transmission and distribu - tion services, construction materials, prefabricated enclosures, agricultural products, heavy machinery, and building fixtures, equipment and services) represent an additional opportunity for the Research Triangle to integrate itself more efficiently into broader economy. Moreover, out of these six clusters, the Research Triangle's national employment share is ranked 34th or better in three of these: power transmission and equipment (15th), prefabricated enclosures (14th), and construction materials (26th).

Exhibit 81: Specialization of the Research Triangle EA, Narrow Cluster Definition



Note: (y-axis, x-axis)
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

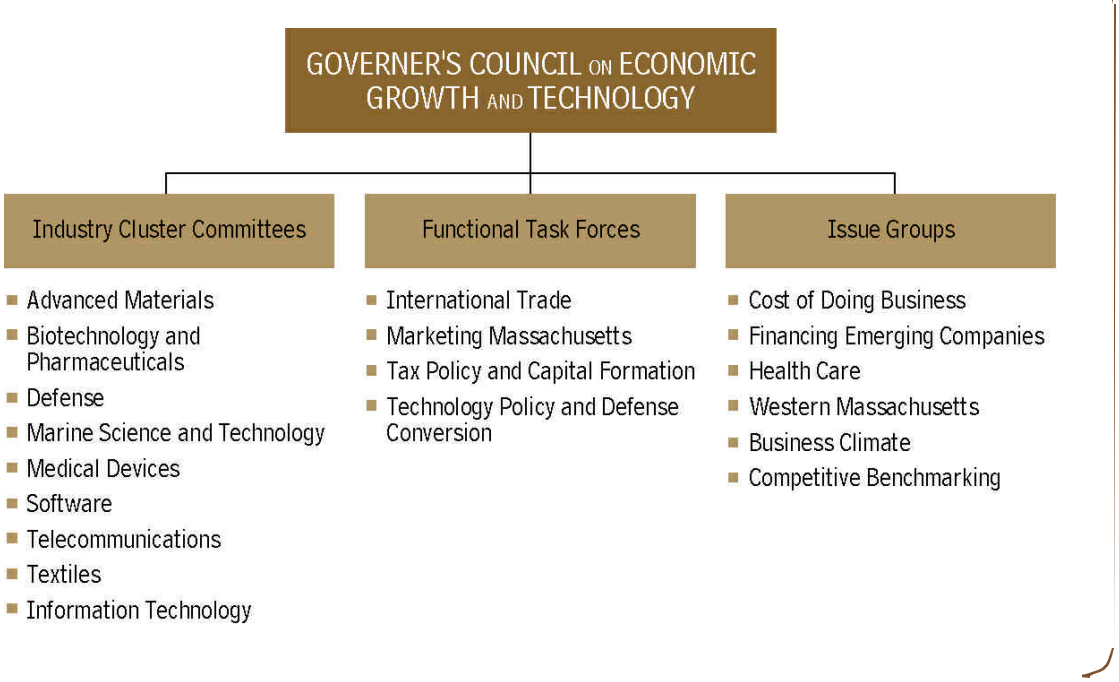
As a result of this broader economic integration, the Research Triangle also has an opportunity to develop closer ties with the financial services cluster and venture capital community in Charlotte, North Carolina, as well as transportation and manufacturing linkages with Atlanta, Georgia by developing the distribution services cluster. Opportunities exist to capitalize on the short distance and historical affinities the Research Triangle community has with the banks in Charlotte; this is also true for the development of relationships with venture capitalists in Charlotte. There is little mention of the specific roles Charlotte-based banks can play in the Research Triangle and their impact on competitiveness beyond the occasional compliment. The region can benefit from the same type of interaction enjoyed by San Francisco's community and San Jose's researchers and entrepreneurs.

Attract and grow more home bases. The Research Triangle community has a lot to offer corporations currently contemplating moving their corporate headquarters. A more concerted marketing and recruiting effort should be directed at insuring that at least one major corporation makes the region its home base. Success in attracting a large corporation to the region will improve corporate involvement in community matters and benefit advocacy for key clusters.

Establish an overarching organization for economic development that helps coordinate and routinize the process. Building a consensus behind a basic agenda is a difficult and ongoing process. Many regions achieve a shared vision primarily due to a crisis that galvanizes the community and spurs action. The Research Triangle region is not in a crisis, yet it seems clear that a new vision is needed. With that new vision must come a new way to formalize a process for working on these issues.

An example from our research is the Massachusetts Governor's Council on Economic Growth and Technology. The Governor's Council was founded in early 1991 to provide expert, objective input on issues and policies relevant to the Massachusetts economy, to report periodically on the status of industry in the Commonwealth, and to make recommendations for policy action and assist in implementation. Composed of the state's leading business executives, academics, and government representatives, the Council exemplifies the philosophy of chief executive involvement and broad-based collaboration in support of private sector-led development. The Council was organized into task forces on tax policy and capital formation, technology policy, and marketing, as well as other committees around important core, and emerging, industry clusters (see Exhibit 82 below).

Exhibit 82: Massachusetts Governor's Council on Economic Growth & Technology



End Notes

1. Michael E. Porter, Hirotaka Takeuchi, Mariko Sakakibara, *Can Japan Compete?*, New York: Perseus Books (2000).
2. See Michael E. Porter, *The Competitive Advantage of Nations*, New York: The Free Press (1990).
3. For an expanded treatment, see Chapter 7 in Michael E. Porter, *On Competition*, New York, The Free Press.
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).
5. In the case of the Research Triangle, the region is defined as the Research Triangle-Chapel Hill MSA , which includes six counties: Chatham, Durham, Franklin, Johnston, Orange, and Wake and the Raleigh-Durham-Chapel Hill EA, which includes the MSA plus 12 additional counties: Edgecombe, Granville, Halifax, Harnett, Lee, Nash, Northampton, Person, Sampson, Vance, Warren, and Wilson.
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.
7. The 1992 Input-Output Accounts measure the share of economic value traded between industries.
8. The Raleigh-Durham-Chapel Hill, MSA was the 12th fastest growing MSA in the nation between 1990 and 2000; US Census Bureau, April, 2001.
9. Richard R. Rogoski, Triangle Business Journal, In Depth: Research Triangle Park 40th Anniversary, January 15, 1999 print edition, "State's future hinged on the Research Triangle Park success."
10. James C. Cobb, *The Selling of the South — The Southern Crusade for Industrial Development*, *1936—1980*, Louisiana State University Press, Baton Rouge (1982).
11. Clusters of Innovation Initiative Interview, November 6, 2000.
12. Clusters of Innovation Initiative Interview, November 7, 2000.
13. Clusters of Innovation Initiative Interview, November 7, 2000.
14. Clusters of Innovation Initiative Interview, November 10, 2000.
15. This number includes government and farm labor that is not included in the CMP data.
16. Cost of living data in these paragraphs taken from the ACCRA — American Chamber of Commerce Research Association, Bankrate.com, and Money Magazine.
17. MIT Enterprise Technology Review, September 2001.
18. Data for this paragraph comes from the Employment Security Commission of North Carolina website.

19. Jobs in traded industries pay about $16,900 more per year than jobs in non-traded industries.
20. Fortune Magazine, Monday, April 16, 2001.
21. Clusters of Innovation Initiative Interview, January 15, 2001.
22. Clusters of Innovation Initiative Interview November 7, 2000.
23. Richard R. Rogoski, The Triangle Business Journal In Depth: Research Triangle Park 40th Anniversary, January 15, 1999 print edition, "State's future hinged on the Research Triangle Park success."
24. Fred M. Park, Metro Magazine, Vol. 1,1 "The Research Triangle Park: The Inside Story."
25. Jeff Miller, The Triangle Business Journal In Depth: Research Triangle Park, October 15, 1999 print edition. "Federal agencies funnel funds to the Research Triangle Park."
26. Industries appear in more than one cluster (e.g., noncommercial research institutions are in both biotechnology/pharmaceutical and communications). One consequence of this is that employment totals of several clusters double-count some workers. To solve this problem, the CMP identified narrow cluster definition. All industries are narrow cluster definition in one cluster, and one cluster only. In addition, many industries are broad cluster definition in other clusters. For example, noncommercial research institutions are a narrow industry in the education and knowledge creation cluster, and are a broad industry in several other clusters, including biotechnology/pharmaceuticals and communications equipment.
27. 32,312 jobs out of the 51,014 total created (or 63.3% of the total).
28. 52,634 jobs out of the 65,339 total created (or 82.1% of the total).
29. Richard R. Rogoski, The Triangle Business Journal In Depth: Research Triangle Park 40th Anniversary, January 15, 1999 print edition, "State's future hinged on the Research Triangle Park success.
30. Michelle Vanstory, Triangle Business Journal In Depth: Research Triangle Park 40th Anniversary, January 15, 1999 print edition "Two original tenants saw park plans unfold."
31. Michelle Vanstory, Triangle Business Journal In Depth: Research Triangle Park 40th Anniversary, January 15, 1999 print edition "Two original tenants saw park plans unfold."
32. Matthew Burns, The Triangle Business Journal In Depth: Research Triangle Park, May 14, 1999 print edition, "Research-only regs too restrictive."
33. David Strow, The Triangle Business Journal In Depth: Research Triangle Park, April 4, 1997 print edition, "New boss key to Big Blue turnaround."
34. Clusters of Innovation Initiative Regional Survey™.
35. Clusters of Innovation Initiative Interview, November 7, 2000.
36. Bill McCoy, The Charlotte Business Journal, January 22, 1999 print edition, "Education must improve for Charlotte to compete."
37. North Carolina Rural Economic Development Center website.
38. National Science Foundation Caspar Database.
39. National Science Foundation Caspar Database.
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41. North Carolina Department of Public Instruction, National Center for Educational Statistics.
42. Clusters of Innovation Initiative Interview, January 15, 2001.

43. Clusters of Innovation Initiative Interview, November 8, 2000.

44. Clusters of Innovation Initiative Interview, May 15, 2001.

45. Richard R. Rogoski, Triangle Business Journal, In Depth: Research Triangle Park, February 11, 2000 print edition, "Untangling traffic will take patience."

46. Clusters of Innovation Initiative Interview, January 15, 2001.

47. Clusters of Innovation Initiative Interview, November 8, 2000.

48. Clusters of Innovation Initiative Interview, January 17, 2001.

49. Pat Youden, Triangle Business Journal, In Depth: Research Triangle Park, February 11, 2000 print edition, "Park perks still attractive to companies."

50. Matthew Burns, Triangle Business Journal, In Depth: A Century of Triangle Business, December 24, 1999 print edition. "Development Deals Transforms Triangle."

51. Daniel Pearson, Triangle Business Journal, August 12, 2001, "Midway files Chapter 11, looks for financing or buyer," Midway Airlines' website.

52. North Carolina Rural Economic Development Center website.

53. Clusters of Innovation Initiative Interview, November 8, 2000.

54. North Carolina Rural Economic Development Center website.

55. Clusters of Innovation Initiative Interview, November 8, 2000.

56. Clusters of Innovation Initiative Interview, January 15, 2001.

57. Clusters of Innovation Initiative Interview, November 8, 2000.

58. Clusters of Innovation Initiative Interview, November 9, 2000.

59. Denise Sherman, Triangle Business Journal, In Depth: A Century of Triangle Business, December 24, 1999 print edition, "A historical tour of Triangle industries."

60. Clusters of Innovation Initiative Interview, November 10, 2000.

61. Jeff Miller, Triangle Business Journal, In Depth: Research Triangle Park, October 15, 1999 print edition, "Federal agencies funnel funds to the Research Triangle Park."

62. Jeff Miller, Triangle Business Journal, In Depth: Research Triangle Park, October 15, 1999 print edition, "Federal agencies funnel funds to the Research Triangle Park."

63. Jeff Miller, Triangle Business Journal, In Depth: Research Triangle Park, October 15, 1999 print edition, "Federal agencies funnel funds to the Research Triangle Park."

64. Richard R. Rogoski, The Triangle Business Journal, In Depth: Research Triangle Park 40th Anniversary, January 15, 1999 print edition, "State's future hinged on the Research Triangle Park success."

65. Zenda Douglas, Triangle Business Journal, In Depth: Triangle tech news, March 24, 2000 print edition. "Bioinformatics spawns revolution."

66. Staff Report, Triangle Business Journal, In Depth: Research Triangle Park, February 11, 2000 print edition the Research Triangle Park newcomers settle in at park,

67. Jennifer S. Corser, The Triangle Business Journal, In Depth: Research Triangle Park 40th Anniversary, January 15, 1999 print edition, "Location lures foreign companies."

68. Matthew Burns, Triangle Business Journal, Exclusive Reports, May 15, 1998 print edition, "Bayer taps the Research Triangle Park for R&D."
69. Cluster Mapping Project Institute for Strategy and Competitiveness, Harvard Business School.
70. Location quotient is a widespread measure of concentration. The formula is a region's share of employment in a cluster/that region's share of total national employment.
71. Cluster Mapping Project Institute for Strategy and Competitiveness, Harvard Business School.
72. Location quotient is a widespread measure of concentration. The formula is a region's share of employment in a cluster/that region's share of total national employment.
73. Catherine L. Traugot, Triangle Business Journal, In Depth: Research Triangle Park, February 11, 2000 print edition, "Biotech figures big into park's future."
74. Note that not all of the employment in the commercial physical research organizations sub-cluster is in the biosciences. Though lack of data prevents precise measure of the number of bioscience researchers, a majority of the Research Triangle's research organizations are bioscience focused.
75. Clusters of Innovation Initiative Interview January 17, 2001.
76. Clusters of Innovation Initiative Interview May 16, 2001.
77. Amal Sabi, Triangle Business Journal, In Depth: Triangle Tech News, July 23, 1999 print edition, "Number of university spin-offs accelerating."
78. MIT Enterprise Technology Review, September 2001.
79. Richard R. Rogoski, Triangle Business Journal, In Depth: Research Triangle Park, May 14, 1999 print edition, "From lab to market, universities fill niche."
80. Amal Sabi, Triangle Business Journal, In Depth: Triangle Tech News, July 23, 1999 print edition, "Number of university spin-offs accelerating."
81. Clusters of Innovation Initiative Regional Survey™.
82. Specialized inputs would include products like chemicals, lab equipment, and biomedical instruments.
83. Clusters of Innovation Initiative Interview, November 9, 2000.
84. Clusters of Innovation Initiative Interview, November 9, 2000.
85. Clusters of Innovation Initiative Interview, May 16, 2001.
86. Clusters of Innovation Initiative Interview May 15, 2001.
87. Clusters of Innovation Initiative Interview May 16, 2001.
88. Clusters of Innovation Initiative Regional Survey™.
89. Fred M. Park, Metro Magazine, Vol. 1, 1, "The Research Triangle Park: The Inside Story."
90. North Carolina State University website.
91. Daniel Pearson, Triangle Business Journal, Exclusive Reports, April 20, 2001 print edition, "Nerves fragile as Cisco hones ax for job cuts."
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93. Clusters of Innovation Initiative Interview, January 15, 2001.

94. David Mildenberg, The Triangle Business Journal, Exclusive Reports, October 3, 1997 print edition, "Cisco leader focusing on the Research Triangle Park growth."

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99. Catherine Traugot, Triangle Business Journal, In Depth: Triangle Tech News, March 23, 2001 print edition, "Optical research attracts fiber firms."

100. The Research Triangle MSA's employment location quotient of 2.94 made it the third most concentrated of the a leading communications equipment cluster MSAs.

101. The Research Triangle EA's employment location quotient of 3.79 made it the third most concentrated of the a leading communications equipment cluster EAs.

102. US Patent & Trademark Office.

103. PWC MoneyTree Database.

104. Suzy Barile, Triangle Business Journal, In Depth: Telecommunications, January 26, 2001 print edition, "Training programs feed the need for techies."

105. Todd Cohen, Triangle Business Journal, May 7, 2001, "Giving staff shaved as Cisco cuts force."

106. Clusters of Innovation Initiative Regional Survey™.

107. Clusters of Innovation Initiative Regional Survey™

108. Cluster Mapping Project Institute for Strategy and Competitiveness, Harvard Business School. As an EA there were 643 net new establishments, 19th highest total in 1999 and 1990.

109. Clusters of Innovation Interview May 15, 2001.

110. Clusters of Innovation Initiative Regional Survey™.

111. Clusters of Innovation Initiative Regional Survey™.

112. Clusters of Innovation Initiative Regional Survey™.

113. Denise Sherman, Triangle Business Journal, In Depth: A Century of Triangle Business, December 24, 1999 print edition, "Mills, tobacco and schools create jobs."

114. Richard R. Rogoski, Triangle Business Journal, In Depth: A Century of Triangle Business, December 24, 1999 print edition, "100 years of Triangle products."

115. Michelle Vanstory, Triangle Business Journal , In Depth: Research Triangle Park 40th Anniversary, January 15, 1999 print edition, "Two original tenants saw park plans unfold."

116. Joe Johnson, Triangle Business Journal, In Depth: Research Triangle Park, February 11, 2000 print edition, "Associations raise profile of park."

117. Clusters of Innovation Initiative Interviews, November 2000, January 2001, and May 2001.

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
Exports	Value of manufacturing and non-manufacturing commodity exports per industry and 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.	U.S. 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 MoneyTree Database
Fast Growth Firms	Number of companies on Inc. 500 list and/or Gazelle-type company per MSA	Direct use of data Inc. 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

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	U.S. 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	North Carolina Department of Education, National Center for Education Statistics, Charlotte Business Journal
Physical infrastructure	Transportation System, Communications System, Utilities	Direct use of data	Research Triangle Owners and Tenants Association Smart Commute 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	American Chamber of Commerce Research Association, Bankrate.com, Money Magazine, Clusters of Innovation Initiative Regional Survey™ Data

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 251 executives at companies and institutions throughout the region. Of the total, 125 were companies from the pharmaceutical / biotechnology and communications equipment cluster, and 126 were from regional institutions of collaboration and other non-cluster organizations (e.g., venture capital firms, banks).

Our team conducted in-depth interviews with 47 individuals in the Research Triangle region. Of these, 17 were with business executives in the pharmaceutical / biotechnology and communications equipment cluster, 30 were executives in other clusters or representatives from academic, government, or institutions for collaboration.

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** *Primarily benefited those with high wealth or high skills*	116	3.76	32.8%	19.8%	47.4%
The overall quality of transportation (e.g., roads, air transport, railroads and ports) is…	**1** *Rarely contribute to cluster-wide programs* **7** *Frequently contribute to cluster-wide programs*	116	4.03	45.7%	14.7%	39.7%
Specialized facilities for research (e.g., science laboratories, university research institutions and technical libraries) are…	**1** *Unsophisticated and undemanding* **7** *Sophisticated and demanding*	115	5.97	92.2%	6.1%	1.7%
The institutions in your region that perform basic research…	**1** *Discouraged by state and regional taxes and incentives* **7** *Encouraged by state and regional taxes and incentives*	112	5.01	68.8%	17.9%	13.4%
The communications infrastructure (including internet access) in your region…	**1** *Very poor relative to other regions* **7** *Very good relative to other regions*	116	5.66	87.9%	7.8%	4.3%
Qualified scientists and engineers in your region are…	**1** *Mostly not available inside your region* **7** *Mostly available inside your region*	116	5.14	72.4%	12.1%	15.5%
The available pool of skilled workers in your region…	**1** *Infrequently* **7** *Frequently*	116	4.16	46.6%	18.1%	35.3%
The overall quality of the K-12 education system is…	**1** *Are inappropriate and hinder your firm's ability to succeed* **7** *Are appropriate and assist you firm's ability to succeed*	116	3.95	38.8%	25.0%	36.2%

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** *Is too small and hinders your growth* **7** *Is sufficient to meet your growth needs*	116	5.60	85.3%	8.6%	6.0%
Training for computer and internet technology is…	**1** *Scarce* **7** *In ample supply*	116	5.29	74.1%	19.0%	6.9%
Local access to risk capital (e.g. venture funds and private equity investments) is…	**1** *Have no preference for the geographic of their business partners* **7** *Prefer to work with firms located in the region*	113	4.04	40.7%	29.2%	30.1%
The overall quality of life (e.g., climate, cultural and recreational opportunities) in the region)…	**1** *Mild* **7** *Intense*	115	5.97	93.0%	4.3%	2.6%
The cost of living in your region…	**1** *Fails to satisfy your business needs* **7** *Fully satisfies your business needs*	115	4.70	63.5%	18.3%	18.3%
Recent economic growth in your region has	**1** *High relative to other regions* **7** *Low relative to other regions*	115	4.56	58.3%	13.9%	27.8%
Regional customers for your business's products/services are…	**1** *Not available to all regional residents* **7** *Available to all regional residents*	72	5.24	75.0%	13.9%	11.1%
Regional customers for your business' products/services have…	**1** *Provide your business with low quality employees* **7** *Provide your business with high quality employees*	72	4.86	59.7%	20.8%	19.4%

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
Feedback from regional customers to improve your business's products/services is…	**1** *Difficult* **7** *Easy*	71	4.39	45.1%	31.0%	23.9%
State and regional regulations affecting your business are…	**1** *Of very low quality* **7** *Comparable with the best quality elsewhere*	72	4.31	48.6%	27.8%	23.6%
The state and regional environmental standards and safety regulations…	**1** *Makes recruitment and retention of employees difficult* **7** *Makes recruitment and retention of employees easy*	114	4.62	47.4%	42.1%	10.5%
Investment in R&D is…	**1** *Do little to assist your R&D efforts* **7** *Are very important to your R&D efforts*	115	4.56	53.9%	27.0%	19.1%
State and local government support for investment in R&D (e.g. funding business incubators, creating consortia)…	**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*	115	4.37	50.4%	27.0%	22.6%
Government's overall responsiveness and ability to work with the needs of business is…	**1** *Low* **7** *High*	113	4.62	60.2%	14.2%	25.7%
The number of regional competitors for your business in your region is…	**1** *Very poor* **7** *Very high*	72	3.63	41.7%	6.9%	51.4%
Regional competition in your industry is…	**1** *Limited* **7** *Readily available*	73	3.81	42.5%	13.7%	43.8%

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
Specialized suppliers of your business's materials, components, machinery, and services are…	**1** *Makes recruitment and retention of employees difficult* **7** *Makes recruitment and retention of employees easy*	72	4.07	50.0%	8.3%	41.7%
Regional specialized suppliers of your business's materials, components, machinery, and services are…	**1** *Rarely transfer knowledge to your industry* **7** *Frequently transfer knowledge to your industry*	71	4.97	64.8%	21.1%	14.1%
Regional specialized suppliers assist your firm with new product and process development …	**1** *Are lax* **7** *Are strict*	70	3.86	34.3%	27.1%	38.6%
Businesses in your region…	**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*	70	4.16	38.6%	40.0%	21.4%
Your cluster…	**1** *Is scant* **7** *Is ample*	72	3.89	43.1%	18.1%	38.9%
Relationships between firms and organizations in your cluster…	**1** *Infrequently share knowledge* **7** *Frequently share knowledge*	71	3.41	26.8%	25.4%	47.9%
Associations and organizations that represent your cluster…	**1** *Low* **7** *High*	72	3.86	41.7%	18.1%	40.3%
Firms in your cluster…have no preference for the geographic location of their business partners	**1** *No special needs that impact your product offering* **7** *Special needs that often impact your product offering*	71	3.49	28.2%	23.9%	47.9%

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…(knowledge sharing) — see coding for scale points	**1** *Hide information from other firms even when there is not a competitive reason to do so* **7** *Share information openly with other businesses*	72	3.63	29.2%	26.4%	44.4%
Firms and organizations 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*	84	3.75	36.1%	20.8%	43.1%
Firms and organizations in your cluster…(willingness to accept new members—see coding for scale end points)	**1** *Do not exist or are ineffective* **7** *Exist and effectively promote the interests of the cluster*	72	4.28	41.7%	34.7%	23.6%
Firms in your cluster…(advantage in perceiving buyer trends—see coding for scale end points)	**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*	68	3.85	30.9%	44.1%	25.0%

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

Measure	Description of Rating Scale	Number of Respondents	Mean	Poor Location	Neutral	Good Location
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*	115	5.46	7.8%	8.7%	83.5%

Measure	Description of Rating Scale	Number of Respondents	Average	<25%	25%–49%	50%–74%	>75%
What proportion of idea generation and 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*	68	3.40	5.9%	13.2%	16.2%	64.7%
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*	65	3.46	7.7%	13.8%	3.1%	75.4%

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY™

Measure	Description of Rating Scale	Number of Respondents	Average	Frequently	Sometimes	Never
develop: Universities	**1** *Never* **2** *Sometimes* **3** *Frequently*	70	1.90	21.4%	47.1%	31.4%
develop: Community Colleges	**1** *Never* **2** *Sometimes* **3** *Frequently*	68	1.32	5.9%	20.6%	73.5%
develop: Public or Private Research Centers	**1** *Never* **2** *Sometimes* **3** *Frequently*	70	1.47	5.7%	35.7%	58.6%
develop: Regional Customers	**1** *Never* **2** *Sometimes* **3** *Frequently*	69	1.87	17.4%	52.2%	30.4%
develop: Other Firms in Your Industry	**1** *Never* **2** *Sometimes* **3** *Frequently*	68	1.88	17.6%	52.9%	29.4%
develop: Regional Suppliers	**1** *Never* **2** *Sometimes* **3** *Frequently*	68	1.75	10.3%	54.4%	35.3%
develop: Venture Capital Firms	**1** *Never* **2** *Sometimes* **3** *Frequently*	68	1.25	5.9%	13.2%	80.9%
develop: Business Incubators	**1** *Never* **2** *Sometimes* **3** *Frequently*	66	1.21	3.0%	15.2%	81.8%
develop: Industry or Cluster Associations	**1** *Never* **2** *Sometimes* **3** *Frequently*	68	1.54	11.8%	30.9%	57.4%
develop: Business Assistance Centers (SBA)	**1** *Never* **2** *Sometimes* **3** *Frequently*	68	1.38	2.9%	32.4%	64.7%

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY™

Measure	Description of Rating Scale	Number of Respondents	Average	Frequently	Sometimes	Never
commerce: Universities	**1** *Never* **2** *Sometimes* **3** *Frequently*	69	1.36	4.3%	27.5%	68.1%
commerce: Community Colleges	**1** *Never* **2** *Sometimes* **3** *Frequently*	67	1.15	1.5%	11.9%	86.6%
commerce: Public or Private Research Centers	**1** *Never* **2** *Sometimes* **3** *Frequently*	69	1.28	1.4%	24.6%	73.9%
commerce: Regional Customers	**1** *Never* **2** *Sometimes* **3** *Frequently*	69	1.77	13.0%	50.7%	36.2%
commerce: Other Firms in Your Industry	**1** *Never* **2** *Sometimes* **3** *Frequently*	67	1.73	11.9%	49.3%	38.8%
commerce: Regional Suppliers	**1** *Never* **2** *Sometimes* **3** *Frequently*	66	1.62	3.0%	56.1%	40.9%
commerce: Venture Capital Firms	**1** *Never* **2** *Sometimes* **3** *Frequently*	67	1.13	1.5%	10.4%	88.1%
commerce: Business Incubators	**1** *Never* **2** *Sometimes* **3** *Frequently*	67	1.12	0.0%	11.9%	88.1%
commerce: Industry or Cluster Associations	**1** *Never* **2** *Sometimes* **3** *Frequently*	67	1.36	6.0%	23.9%	70.1%
commerce: Business Assistance Centers (SBA)	**1** *Never* **2** *Sometimes* **3** *Frequently*	67	1.25	0.0%	25.4%	74.6%

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* **DK** *or* **NA**	59	4.78	61.0%	25.4%	13.6%
sat: Community Colleges	**1** *Unsatisfied* **7** *Satisfied* **DK** *or* **NA**	37	4.24	35.1%	45.9%	18.9%
sat: Public or Private Research Centers (salk, scripps)	**1** *Unsatisfied* **7** *Satisfied* **DK** *or* **NA**	46	4.15	30.4%	54.3%	15.2%
sat: Regional Customers	**1** *Unsatisfied* **7** *Satisfied* **DK** *or* **NA**	55	4.84	56.4%	36.4%	7.3%
sat: Other Firms in Your Industry	**1** *Unsatisfied* **7** *Satisfied* **DK** *or* **NA**	55	4.78	54.5%	38.2%	7.3%
sat: Regional Suppliers	**1** *Unsatisfied* **7** *Satisfied* **DK** *or* **NA**	55	4.60	49.1%	38.2%	12.7%
sat: Venture Capital Firms	**1** *Unsatisfied* **7** *Satisfied* **DK** *or* **NA**	41	3.78	22.0%	51.2%	26.8%
sat: Business Incubators	**1** *Unsatisfied* **7** *Satisfied* **DK** *or* **NA**	39	3.67	15.4%	59.0%	25.6%
sat: Industry Associations	**1** *Unsatisfied* **7** *Satisfied* **DK** *or* **NA**	46	4.20	39.1%	37.0%	23.9%
sat: Business Assistance Centers (RTA, SBA)	**1** *Unsatisfied* **7** *Satisfied* **DK** *or* **NA**	43	4.26	44.2%	39.5%	16.3%

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	Helpful	Neutral	Not Helpful
enterpren: University-based networking organizations	**1** *Not at all helpful* **5** *Critically helpful*	109	2.74	27.5%	30.3%	42.2%
enterpren: University technology transfer offices	**1** *Not at all helpful* **5** *Critically helpful*	109	2.65	23.9%	34.9%	41.3%
enterpren: Regional industry or cluster councils	**1** *Not at all helpful* **5** *Critically helpful*	108	2.96	37.0%	31.5%	31.5%
enterpren: National trade associations	**1** *Not at all helpful* **5** *Critically helpful*	107	2.68	18.7%	42.1%	39.3%
enterpren: Economic development organizations	**1** *Not at all helpful* **5** *Critically helpful*	108	2.92	33.3%	31.5%	35.2%
estab co: University-based networking organizations	**1** *Not at all helpful* **5** *Critically helpful*	111	2.57	18.9%	30.6%	50.5%
estab co: University technology transfer offices	**1** *Not at all helpful* **5** *Critically helpful*	111	2.48	15.3%	34.2%	50.5%
estab co: Regional industry or cluster councils	**1** *Not at all helpful* **5** *Critically helpful*	110	2.82	30.9%	33.6%	35.5%
estab co: National trade associations	**1** *Not at all helpful* **5** *Critically helpful*	110	2.88	32.7%	35.5%	31.8%
estab co: Economic development organizations	**1** *Not at all helpful* **5** *Critically helpful*	110	2.80	31.8%	30.9%	37.3%

Helpful = 4,5 Neutral = 3 Not Helpful = 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** *Disagree* **7** *Agree*	114	3.49	29.8%	14.0%	56.1%
Intense local competition between companies tends to contribute positively to the standard of living of the average citizen	**1** *Disagree* **7** *Agree*	114	4.50	57.0%	14.9%	28.1%
Companies that compete against each other in the region should establish closer ties and cooperative agreements than they have now.	**1** *Disagree* **7** *Agree*	114	4.37	49.1%	25.4%	25.4%
Entry of a new competitor in the region benefits the business environment	**1** *Disagree* **7** *Agree*	115	2.39	7.0%	8.7%	84.3%
Companies in close geographic proximity often end up sharing information that they otherwise would not	**1** *Disagree* **7** *Agree*	114	4.82	68.4%	12.3%	19.3%
Presence of intense local competition between companies tends to foster innovation.	**1** *Disagree* **7** *Agree*	115	5.57	92.2%	1.7%	6.1%
Where possible, companies should seek to train workers through cooperative training programs, rather than on their own.	**1** *Disagree* **7** *Agree*	115	4.57	51.3%	27.0%	21.7%
For most firms, the benefits of having local competitors outweigh the costs	**1** *Disagree* **7** *Agree*	115	4.63	54.8%	25.2%	20.0%

Agree = 5,6,7 Helpful = 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** *Disagree* **7** *Agree*	113	3.35	16.8%	32.7%	50.4%
Employees at every level of a company should be encouraged to exchange non-proprietary information with their peers at other firms.	**1** *Disagree* **7** *Agree*	115	3.88	42.6%	13.0%	44.3%
It is possible for companies to collaborate and compete at the same time	**1** *Disagree* **7** *Agree*	115	5.19	75.7%	6.1%	18.3%
Cooperation between local firms has contributed directly to the prosperity of the region as a whole.	**1** *Disagree* **7** *Agree*	115	5.01	67.0%	19.1%	13.9%
Companies are worse off when they have to compete with other local companies to attract and retain skilled workers	**1** *Disagree* **7** *Agree*	115	3.61	28.7%	18.3%	53.0%
Intense local competition between companies tends to help them increase productivity	**1** *Disagree* **7** *Agree*	114	5.01	72.8%	17.5%	9.6%
Firms in clusters…are better prepared to compete vs. isolated competitors	**1** *Disagree* **7** *Agree*	114	5.42	78.1%	14.9%	7.0%
Firms in clusters…benefit indirectly when other firms in the cluster succeed	**1** *Disagree* **7** *Agree*	114	5.21	78.1%	12.3%	9.6%

Agree = 5,6,7 Helpful = 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*	114	4.18	43.9%	21.9%	34.2%
Firms in clusters…innovate at the same rate as firms not in clusters	**1** *Agree* **7** *Disagree*	114	5.20	75.4%	15.8%	8.8%
Firms in clusters…are more susceptible to downturns in their industry	**1** *Agree* **7** *Disagree*	114	3.40	18.4%	30.7%	50.9%

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

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*	71	2.99	36.6%	32.4%	31.0%
In five years, how beneficial do you think your physical location in San Diego will be to your firm's ability to innovate?	**1** *Agree* **7** *Disagree*	71	3.04	40.8%	31.0%	28.2%

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

Measure	Description of Rating Scale	Number of Respondents	Average	Fundamental Impact	Some Impact	Significant Impact	Hardly At All
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*	72	2.15	9.7%	22.2%	41.7%	26.4%

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY

Measure	Description of Rating Scale	Number of Respondents	Average	Not Important	Neutral	Important
Promote world-class primary and secondary education	**1** *Not at all important* **5** *Critically important*	114	4.46	3.5%	7.0%	89.5%
Promote specialized education and training programs to upgrade worker skills	**1** *Not at all important* **5** *Critically important*	114	4.11	3.5%	18.4%	78.1%
Implement tax reform to encourage investment in innovation (e.g., R&D tax credits)	**1** *Not at all important* **5** *Critically important*	113	3.58	15.9%	26.5%	57.5%
Speed up regulatory approval processes in line with product life-cycles	**1** *Not at all important* **5** *Critically important*	113	3.34	20.4%	30.1%	49.6%
Simplify compliance procedures for government regulations (e.g., one-stop filing, websites, etc)	**1** *Not at all important* **5** *Critically important*	113	3.58	14.2%	31.0%	54.9%
Reform liability laws to stimulate and reward next generation product innovation and safety	**1** *Not at all important* **5** *Critically important*	113	3.25	24.8%	37.2%	38.1%
Promote antitrust legislation to encourage competition	**1** *Not at all important* **5** *Critically important*	112	2.38	59.8%	26.8%	13.4%
Support the particular needs of start-up companies (access to capital, incubators, management training)	**1** *Not at all important* **5** *Critically important*	113	3.62	15.0%	33.6%	51.3%
Strengthen and modernize intellectual property protections (patents, copyrights) at home and abroad	**1** *Not at all important* **5** *Critically important*	112	3.54	15.2%	30.4%	54.5%
Provide services to assist and promote regional exports	**1** *Not at all important* **5** *Critically important*	113	2.96	26.5%	46.0%	27.4%

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	Not Important	Neutral	Important
Improve information and communications infrastructure	**1** *Not at all important* **5** *Critically important*	114	3.47	19.3%	28.1%	52.6%
Assist in attracting suppliers and service providers from other locations	**1** *Not at all important* **5** *Critically important*	111	2.93	40.5%	28.8%	30.6%
Promote universal computer literacy	**1** *Not at all important* **5** *Critically important*	113	3.51	12.4%	34.5%	53.1%
Government support for funding of specialized research institutes, labs, etc.	**1** *Not at all important* **5** *Critically important*	113	3.17	30.1%	31.0%	38.9%
Catalyze partnerships among government, industry and universities.	**1** *Not at all important* **5** *Critically important*	114	3.37	21.9%	32.5%	45.6%
Improve transportation and other physical infrastructure	**1** *Not at all important* **5** *Critically important*	114	4.37	1.8%	13.2%	85.1%
Increase funding for university-based research	**1** *Not at all important* **5** *Critically important*	113	3.32	23.9%	30.1%	46.0%

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

Measure	Description of Rating Scale	Number of respondents	Average	Regionally based, regional sales	Regionally based, sell in region and outside	Unit of US company based elsewhere	Unit of foreign company
Which best describes the type of firm where you work?	**1** *Regionally based, sells primarily in region* **2** *Regionally based, sell both in region and outside* **3** *Unit of US co based elsewhere* **4** *Unit of foreign company*	71	2.38	14.1%	52.1%	15.5%	18.3%

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY™

Measure	Description of Rating Scale	Number of respondents	Average	End Consumer Manufac-tured Product	Busi-ness Service	Inter-mediate Input	Technical/ IT Support Product	Other
Which best describes your primary line of business	**1** *End-consumer Manufactured Product* **2** *Business Service* **3** *Intermediate Input* **4** *Technical/IT support product* **5** *Other*	69	2.43	42.0%	23.2%	5.8%	7.2%	21.7%

Measure	Description of Rating Scale	Number of respondents	prior to 1940	1941-1950	1951-1960	1961-1970	1971-1980	1981-1990	1991-1995	1996-present
When was your organization founded?	**enter year**	89	8.7%	8.7%	7.2%	7.2%	33.3%	23.2%	11.6%	0.0%

Measure	Description of Rating Scale	Number of respondents	Small	Medium	Large
Approximate Number of Employees	**enter number**	71	56.3%	31.0%	12.7%

Measure	Description of Rating Scale	Number of respondents	Average	1	2	3	4	5	6
Revenue Category	**1** *<$1 million* **2** *1 to 10 mill* **3** *11 to 50 mill* **4** *51 to 100 mill* **5** *101 to 300 mill* **6** *300 mill plus*	69	2.45	31.9%	27.5%	24.6%	2.9%	5.8%	7.2%

Measure	Description of Rating Scale	Number of Respondents	Average	Spend Less	Spend Same	Spend More
Relative to your competitors in your industry, how would you describe your firm's expenditures on R&D?	**1** *Spend far less* **2** *Spend somewhat less (on a % basis) than competitors* **3** *Spend about the same (on a & basis) than competitors* **4** *Spend somewhat more (on a % basis) than competitors* **5** *Spend far more (on a % basis) than competitors*	57	3.61	14.0%	28.1%	57.9%

Measure	Description of Rating Scale	Number of respondents	Average	1	2	3	4	5
Please estimate your company's average annual revenue growth over the past three years	**1** *Negative or 0%* **2** *1 to 10%* **3** *11 to 20%* **4** *20 to 100%* **5** *Over 100%*	65	3.83	15.4%	30.8%	15.4%	27.7%	10.8%

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY™

Measure	Description of Rating Scale	Number of Respondents	Average	Better than Average	Average	Worse than Average
Looking back over the past 5 years, how would you rate your company's performance relative to your company's competitors?	*1 Among the best in the industry* *2 Significantly better than average* *3 Somewhat better than average* *4 Just about average* *5 Somewhat worse than average* *6 Significantly worse than average* *7 Among the worst in the industry*	59	2.53	6.8%	11.9%	81.4%
		8.7%	8.7%	7.2%	7.2%	33.3%	23.2%	11.6%	0.0%

Measure	Description of Rating Scale	Number of respondents	Average	1	2	3	4	5
Which best describes your position in your firm?	**1** *Owner, president, CEO* **2** *Sr. Executive/Sr. Official* **3** *Manager* **4** *Other*	108	1.79	48.1%	33.3%	10.2%	8.3%	
Education (Check highest completed)	**1** *Some secondary school* **2** *Secondary school* **3** *Some college* **4** *College graduate* **5** *Graduate Degree*	109	4.51	0.0%	0.9%	6.4%	33.0%	59.6%
Age	**1** *20-29* **2** *30-39* **3** *40-49* **4** *50-59* **5** *60 or older*	110	3.44	2.7%	11.8%	34.5%	40.9%	10.0%

Measure	Description of Rating Scale	Number of respondents	Newly Arrived	Established	Longtime Resident
How long have you lived in this area?	*enter years*	106	14.2%	17.0%	67.9%

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY™

Taking into account all the elements of the business environment that you have considered so far, which five currently have the greatest positive impact on your business's success? Which factors do you consider to be the greatest future threats to your business if not addressed? Please check off five (5) of the elements on the list below for both the Positive and Future Threat columns.

	Number of Respondents	Present	Future
Cost of doing business	44	16.4%	37.9%
Quality of transportation	45	10.3%	38.8%
Specialized facilities for research	7	22.4%	6.0%
Qualified scientists and engineers	15	35.3%	12.9%
Transfer of knowledge from research institutions	4	12.9%	3.4%
Communications infrastructure	3	13.8%	2.6%
Available pool of skilled workforce	33	18.1%	28.4%
Quality of K-12 education	33	8.6%	28.4%
Sourcing of employees from advanced educational programs	3	20.7%	2.6%
Access to capital	23	11.2%	19.8%
Demanding regional customers that provide feedback	0	5.2%	0.0%
Specialized needs of regional customers	3	4.3%	2.6%
State/local regs for production processes and products/services	12	2.6%	10.3%
State and regional environmental / safety regs	11	8.6%	9.5%
State and regional tax and incentives for investment in R & D	12	4.3%	10.3%
Predictability of government policies	17	5.2%	14.7%
Govt's overall responsiveness to the needs of business	11	4.3%	9.5%
Level of competition in your industry	27	6.0%	23.3%
Quality and in-region location of your suppliers	9	6.9%	7.8%
Assistance from regional suppliers for new product and process development	4	5.2%	3.4%
Relationships between firms and organizations in your cluster	8	11.2%	6.9%
Participation with regional institutions in R & D efforts	5	9.5%	4.3%
Overall quality of life for employees	11	44.0%	9.5%

Please check the areas in which your firm's adoption of e-commerce tools has had a positive influence on your business. (check all that apply)	Number of respondents	Percent of total respondents that checked this option
Eimpact: Increased efficiency of supplier replenishment	72	27.8%
Eimpact: Allowed firm to reduce reliance on distributors	72	4.5%
Eimpact: Improved internal knowledge flow	72	25.2%
Eimpact: Improved quality of information on customers	72	18.8%
Eimpact: Enlarged client base	72	8.4%
Eimpact: Improved worker productivity	72	16.3%
Eimpact: Improved customer and investor access to information about firm	72	22.3%
Current reason: Proximity to regional suppliers to your industry	115	4.5%
Current reason: Proximity to regional client base	115	14.9%
Current reason: Happenstance (Chance/Luck)	115	11.9%
Current reason: Prior relationship with local company	115	11.9%
Current reason: Access to skilled labor	115	29.7%
Current reason: Tax incentives	115	3.0%
Current reason: Air/Water Quality	115	0.5%
Current reason: Low traffic congestion	115	0.5%
Current reason: Proximity to regional research and development centers	115	30.7%
Current reason: Business-friendly political environment	115	16.3%
Current reason: Low cost of labor	115	3.5%
Current reason: Access to raw materials	115	0.5%
Current reason: Proximity to competing firms in your industry	115	5.9%
Current reason: Housing Affordability	115	2.5%
Current reason: low cost of commercial land	115	2.0%
Current reason: Proximity to executives principal residence	114	16.3%
Next 5 years: Proximity to regional suppliers to your industry	115	2.5%
Next 5 years: Proximity to regional client base	115	5.9%
Next 5 years: Access to skilled labor	115	22.3%
Next 5 years: Tax incentives	115	11.4%

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY™

	Number of respondents	Percent of total respondents that checked this option
Next 5 years: Air/Water Quality	115	1.5%
Next 5 years: high income inequality	115	3.0%
Next 5 years: Proximity to regional research and development centers	115	35.1%
Next 5 Years: Traffic Congestion	115	1.0%
Next 5 years: Business-friendly political environment	115	5.9%
Next 5 years: High cost of labor	115	19.8%
Next 5 years: Low access to raw materials	115	0.5%
Next 5 years: Distance from competing firms in your industry	115	2.0%
Next 5 years: High cost of housing	115	16.3%
Next 5 years: High cost of commercial land/property	115	15.8%

ABOUT
THE CLUSTERS OF INNOVATION INITIATIVE PARTICIPANTS

MICHAEL E. PORTER

Michael E. Porter is the Bishop William Lawrence University Professor at Harvard University 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.