

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

Pittsburgh



CLUSTERS OF INNOVATION INITIATIVE



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ISBN 1-889866-52-0

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Professor Michael E. Porter, Harvard University
Monitor Group
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Printed in the United States of America
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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	iv
Acknowledgments	v
National Steering Committee Members and Regional Advisors	vii
Report Overview	viii
Highlights	ix
Executive Summary	xii
Introduction	1
1 Economic Competitiveness and Regional Innovative Capacity	3
2 Regional Study Methodology	14
3 Assessment of the Pittsburgh Regional Economy	20
4 Competitiveness of Selected Clusters	47
The Biotechnology / Pharmaceutical Cluster	47
The Information Technology Cluster	68
The Production Technology Cluster	85
5 Sustaining Competitive Advantage: Lessons, Challenges, and Opportunities	103
Endnotes	117
Appendices	121
1. Definition of Measurements	121
2. Results from the Clusters of Innovation Initiative Regional Survey™	125
3. Contributors to the Pittsburgh Study	145
ABOUT the Clusters of Innovation Initiative Participants	146



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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 been 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 U.S. competitiveness. The nation's ability to produce high-value products and services depends on the creation and strengthening of regional clusters of industries that become hubs of innovation. 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, yields better market insights, more refined research agendas, larger pools of specialized talent, and faster deployment of new knowledge.

Utilizing a unique database developed at the Institute for Strategy and Competitiveness at the Harvard Business School, we are 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, on the FRONTIER, 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 Pittsburgh 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 Pittsburgh 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, we hope, benefit not only the five regions that participated in the study but other parts of the country as well.

A handwritten signature in black ink, appearing to read "F. Duane Ackerman".

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

A handwritten signature in black ink, appearing to read "Michael E. Porter".

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Co-Chair, Clusters of Innovation Initiative
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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, ontheFRONTIER, the Institute for Strategy and Competitiveness at Harvard Business School, and the Council on Competitiveness. Carnegie Mellon University President Jared Cohon provided key insights on the region and on drafts of this report.

The Claude Worthington Benedum Foundation, the Heinz Endowments, the McCune Foundation, and the R.K. Mellon 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. Mike Brennan of ontheFRONTIER 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 and Veronica Ingham.

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.

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 with valuable information and coordination assistance in the region, including Dr. Jared Cohon of the Carnegie Mellon University, Peter Johnson of Tissue Informatics, Brian Kelley of the Heinz Endowments, Elizabeth Lynn of the McCune Foundation, Dwight Keating of the Claude Worthington Benedum Foundation, Michael Watson of the R.K. Mellon Foundation, Sean

McDonald, McKesson HBOL Automated Healthcare, Dick Simmons, Allegheny Teledyne, Sunil Wadhvani, iGATE Capital Corporation, Steve Zylstra, Pittsburgh Technology Council, Donald Smith and Jerry Paytas, Center for Economic Development at Carnegie Mellon University, reviewed and commented on drafts of this report and served as advisors to the project.

Stephanie Weir, Center for Economic Development, helped coordinate interviews, surveys and general logistics in Pittsburgh. Several professors from the University of Pittsburgh and Carnegie Mellon University provided important background information and made helpful suggestions.

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.

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.

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REPORT OVERVIEW

This report is structured to educate the reader on the critical issues in Pittsburgh, then to allow the reader to understand the framework and the methodology that is used to provide an analysis of the data. We then provide the results of the analysis, first at the regional level, followed by an in-depth analysis of the biotechnology, information technology and production technology clusters. Finally, we close the report with a detailed summary of key findings and suggestions.

This report is divided into the following sections:

Highlights provide a very short, high level description of the region's innovation capacity, accomplishments, assets, challenges, new directions and opportunities.

Executive Summary provides a summary of the region's overall performance, as well as the performance of the three studied clusters, with lessons, challenges and new opportunities for Pittsburgh.

Section 1, Economic Competitiveness and Regional Innovative Capacity: provides an overview of the determinants of regional innovation capacity and economic competitiveness.

Section 2, Regional Study Methodology: outlines a methodology for assessing them.

Section 3, Assessment of the Pittsburgh Regional Economy: applies this model of regional economic competitiveness to Pittsburgh. It describes the evolution of the Pittsburgh economy over the course of the 20th century, examines the overall performance and composition of the regional economy, and assesses strengths and challenges in the business environment.

Section 4, Competitiveness of Selected Clusters: examines the performance of important industry clusters—biotechnology /pharmaceuticals, information technology, and production technology—in the region.

Section 5, Sustaining Competitive Advantage: Lessons, Challenges, and Opportunities: draws from the regional and cluster-specific analyses to identify lessons that will inform the national clusters of innovation initiative.

Appendixes review information sources and provide survey findings for total Pittsburgh respondents

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 Pittsburgh to sustain its competitive position and performance.

HIGHLIGHTS

Regional Innovation Capacity and Economic Competitiveness

- The economic goal for Pittsburgh 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.

Pittsburgh's Accomplishments

- Pittsburgh weathered a deep decline in steel and other manufacturing industries in the 1980s.
- Subsequently, the region has established strong positions in advanced manufacturing by creating specialty products.
- Pittsburgh has developed world-class colleges and universities.
- Local entrepreneurs and supporting institutions have demonstrated the ability to create new firms and industries from local knowledge centers.

Assets

These accomplishments have left Pittsburgh with a number of assets:

- High quality of life for families
- Competitive cost position, especially relative to other tech centers
- Experienced manufacturing workforce
- Good workforce training infrastructure
- Broad-based economy with strong manufacturing positions
- Many specialized research centers
- High levels of federal R&D investments at universities
- Positions in fast-growing industry clusters
- Broad array of economic development organizations

Challenges

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

- Difficulties in workforce retention and recruitment
 - Low regional retention rate of college graduates
 - Lack of an effective strategy to recruit outside workers
 - Virtually no in-migration of population and workforce
- Low levels of innovation
 - Low technology transfer and commercialization from universities
 - Low patent growth rates despite increased research levels
- Challenging environment for start-up and growth companies
 - Limited local venture capital in many sectors
 - Limited utilization of networking opportunities
 - Limited availability of specialized support for start-ups and growth firms
- Underdeveloped clusters
 - Relatively weak local supplier base in studied clusters
 - Relatively weak linkages with local customers in studied clusters
- Weak collaboration and coordination
 - Fragmented and regionally divided local government
 - Under-leveraged public and private institutions for collaboration
 - Need for greater collaboration among groups throughout the community
 - Need for shared vision and coordinated leadership
- Aging physical infrastructure and a shrinking tax base

New Directions

Our analysis identifies several themes by which Pittsburgh can transition from a slowly growing economy to a diversified, mature, and strongly performing economy. Pittsburgh should move from:

- A bifurcated economy to a diversified and integrated economy: companies in traditionally manufacturing as well as those in new technology-based fields should collaborate to exploit joint opportunities.
- Excellence of basic research to excellence in commercialization: universities and research centers should focus on improving knowledge commercialization to the private sector.
- A diversity of groups to a collaborative community: the region would benefit from greater networking among its diverse organizations, companies, and communities.

Opportunities

Pittsburgh can seize on a number of under-realized and promising opportunities, but will require collaboration to exploit them:

- Build a global leadership position in both advanced manufacturing and new technologies.
- Better unlock commercial potential in universities:
 - by improving knowledge commercialization (e.g., UCSD CONNECT model)
 - by creating facilities to foster networking (e.g., Centennial Campus model).
 - by creating and leveraging resources outside of the universities (but with university participation) that support technology commercialization, such as the Digital Greenhouse
- Enhance Pittsburgh's position as a medical center by linking with local demand to identify emerging national needs.
- Attract non-university research institutions:
 - to increase the number of local researchers
 - to build bridges between basic university research and industry.
- Enhance and support the agenda and action orientation of cluster-specific organizations.
- Organize and pursue growth opportunities at the intersection of clusters (e.g., tissue engineering, robotics, medical devices and bioinformatics).
- Better leverage the state government to assist in prioritized strengthening of the business environment.
- Market the region's opportunities and strengths both inside and outside the region.

EXECUTIVE SUMMARY

The Determinants of Regional Innovation Capacity and Economic Competitiveness

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

A critical driver of innovation output, 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.

Exhibit 1: Determinants of Regional Productivity

	Common	Cluster-specific
Basic and Specialized Factor Inputs	<ul style="list-style-type: none"> ■ Information and communication infrastructure ■ Skilled workforce ■ Investment in educational capacity ■ Availability of risk capital ■ Quality of life 	<ul style="list-style-type: none"> ■ Presence of specialized research centers ■ Presence of specialized talent base ■ Presence of specialized training and education institutions
Context for Firm Strategy and Rivalry	<ul style="list-style-type: none"> ■ Tax policy (e.g., investment incentives) 	<ul style="list-style-type: none"> ■ Intensity of rivalry among firms in the cluster ■ Degree of cooperation between firms in the cluster
Related and Supporting Industries	<ul style="list-style-type: none"> ■ Regional position in broad based industries such as business services and energy 	<ul style="list-style-type: none"> ■ Extent of related industries inside and outside of the cluster
Sophistication of Demand	<ul style="list-style-type: none"> ■ Overall regional education and per capita income levels 	<ul style="list-style-type: none"> ■ Sophistication of the demand in the region for the clusters' products and services
Government	<ul style="list-style-type: none"> ■ Zoning regulations ■ Coordination between government regional agencies 	<ul style="list-style-type: none"> ■ Cluster-specific regional policies
Institutions of Collaboration	<ul style="list-style-type: none"> ■ Existence of regional institutions of collaboration 	<ul style="list-style-type: none"> ■ Existence of cluster-specific institutions for collaboration
Attitudes toward Value Creation	<ul style="list-style-type: none"> ■ Regional attitudes toward the sources of economic prosperity 	<ul style="list-style-type: none"> ■ Cluster-specific attitudes toward the sources of economic prosperity

- **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, as does the presence of competing local rivals.

- **Related and supporting industries.** Local sourcing from capable suppliers based in the region can enhance productivity and improve the capacity for innovation through allowing quicker and less costly communication, fostering the flow of ideas, and enhancing flexibility through outsourcing.

These four areas 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 a given field.

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

The Role of Government in 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.

Exhibit 2: Institutions for Collaboration in Pittsburgh

Private Sector	Joint Private/Public
<ul style="list-style-type: none"> ■ Pittsburgh Regional Alliance ■ Cluster-specific Organizations—i.e., Pittsburgh Technology Council, including Advanced Biomedical Development Corporation, Advanced Manufacturing Network and the IT Network ■ Manufacturing Assistance Center ■ Advanced Manufacturing Network ■ Industrial Development Authorities ■ Center for Economic Development ■ SPIRC 	<ul style="list-style-type: none"> ■ Pittsburgh Digital Greenhouse ■ Pittsburgh World Trade Center ■ Governor's Action Team/Team PA ■ Allegheny Conference on Community Development ■ Pittsburgh Life Science Greenhouse
Informal Networks	Public Sector
<ul style="list-style-type: none"> ■ Carnegie Mellon University Alumni ■ University of Pittsburgh Alumni ■ Duquesne University Alumni ■ Angel investor community 	<ul style="list-style-type: none"> ■ Small Business Administration ■ Small Business Development Centers ■ SWPA Regional Development Council ■ Innovation Works/Ben Franklin

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

The Composition of Regional Economies

Regional economies are composed of three main types of activities:

- **Local clusters.** These clusters are found in every region and produce goods and services that are needed by the local population (e.g., retail trade).
- **Traded clusters.** Traded clusters produce products and services that are in competition with other regions and nations. They trade across the nation or the globe (e.g., automotive, medical devices). These clusters tend to be concentrated only in a few regions.
- **Natural resource clusters.** Natural resource clusters are found in locations where a particular natural resource is abundant.

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 PITTSBURGH REGIONAL ECONOMY

Economic Performance

The standard of living (wages relative to cost of living) is good in Pittsburgh, but low exports indicate a lack of competitiveness, and the region suffers from a reinforcing cycle of low job creation and an out-migration of young workers.

- **Employment.** Annual employment growth rate from 1991 to 2001 in the Pittsburgh MSA was 0.3% versus 1.9% for the United States.
- **Unemployment.** In 2001, unemployment in Pittsburgh was at 4.3%, which was just below the national average of 4.4%. Unemployment in Pittsburgh is low, despite slow job growth, due in large part to a net out-migration by the younger population and slow population growth.¹ For instance, the last U.S. census shows that more than 30,000 people age 20-29 migrated from Pittsburgh during the 1985-1990 period alone. Additionally, state data from 1997-1998 shows a net decrease of approximately 4% in that age category.
- **Wages.** Pittsburgh's average wages were \$32,365 in 1999, versus \$32,711 for the United States. Annual growth of wages equaled the U.S. growth rate.
- **Cost of living.** The region's average cost of housing is slightly below the national average, and significantly below large technology markets such as Boston, Northern Virginia, and San Jose.
- **Exports.** Pittsburgh's exports of \$3,416 per worker in 1999 were well below the national average of \$5,212 per worker.

Innovation Output

Although current levels of patent registration are above the national average, all other measures of innovation lag national averages, let alone top innovation regions. This raises concerns about future productivity levels and prosperity.

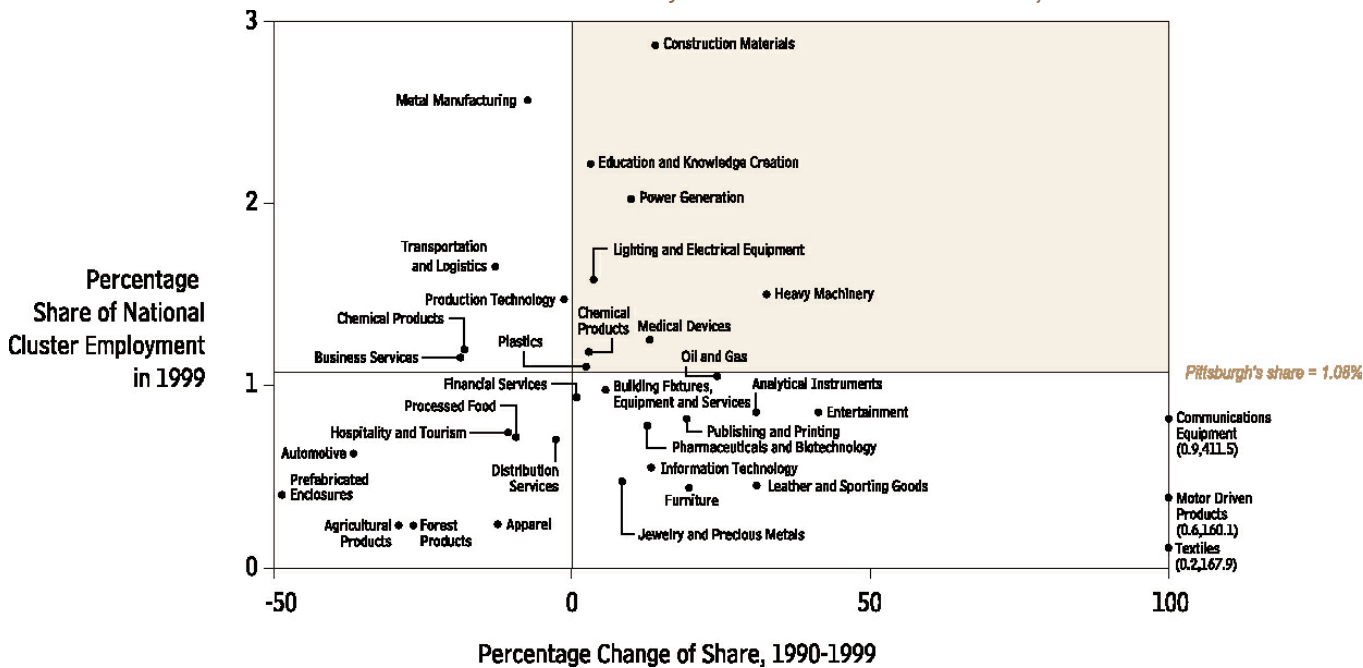
- **Patents.** Pittsburgh firms and organizations registered 7.0 patents per 10,000 workers in 1998, compared to 6.3 for the United States. However, the growth rate of patents per capita in Pittsburgh was 1.3% over the 1990 to 1998 period; well behind the national rate of 4.7%.
- **Venture capital.** Venture capital investments in Pittsburgh in 2000 of \$301 per worker lagged the national average of \$387. Pittsburgh's VC funding has grown 41%² annually from 1995 to 2000, below the national level of 62%³ for the same period. Although Pittsburgh VC funding had solid growth during this period, it should be noted that it not only grew significantly below the national levels, but the national levels are anticipated to retract – creating retraction in Pittsburgh as well.
- **Fast growth firms.** Pittsburgh had 0.8% of the firms on the Inc 500 from 1991–2000 vs. 0.9% of the U.S. employment.
- **Initial public offerings (IPOs).** Pittsburgh had only 0.4 IPOs per 100,000 workers in the past ten years, well below benchmarked regions.
- **Establishment growth.** The number of establishments in Pittsburgh grew at an annual rate of 0.5% between 1990 and 1999, well below the national rate of 1.4%.

Exhibit 3: Summary of Economic Performance and Innovation Output in Pittsburgh

Overall Economy	Innovation Output
<ul style="list-style-type: none"> ▪ Employment <i>Annual employment growth rate between 1991 and 2001 in the Pittsburgh MSA 0.3% vs. 1.9% for the U.S.</i> ▪ Unemployment <i>Unemployment rate in the Pittsburgh MSA of 4.3% in 2001 vs. 4.4% for U.S.</i> ▪ Population <i>The population of the Pittsburgh MSA is decreasing at 0.3% annually between 1990 and 1999 vs. 1.0% growth for the U.S.</i> ▪ Wages <i>Average wage in the Pittsburgh MSA of \$32,365 in 1999, vs. \$32,711 for the U.S.; annual growth of wages equaled the U.S. growth rate</i> ▪ Exports <i>Exports per worker in the Pittsburgh MSA were \$3,416 in 1999 vs. \$5,212 for the U.S.</i> 	<ul style="list-style-type: none"> ▪ Patents <i>7.0 patents per 10,000 workers in the Pittsburgh MSA in 1999 vs. 6.3 for the U.S.; 1.3% annual growth in the MSA vs. 4.7% in U.S. from 1990 to 1999</i> ▪ Fast Growth Firms <i>Pittsburgh had 0.8% of the firms on the Inc 500 list between 1991 and 2000 vs. 0.9% of the U.S. employment</i> ▪ Venture Capital Investments <i>VC investments of \$301 per worker in Pittsburgh in 2000 vs. \$387 for the U.S.</i> ▪ Initial Public Offerings <i>Pittsburgh had 0.4 IPOs per 100,000 workers in the past 10 years, well below benchmarked regions</i> ▪ Established Growth <i>The number of establishments in Pittsburgh grew 0.5% annually between 1990 and 1999, vs. 1.4% for the U.S.</i>

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

Exhibit 4: Specialization of the Pittsburgh Economic Area:
Traded Clusters by Relative Size and Growth Rate, Narrow Cluster Definition

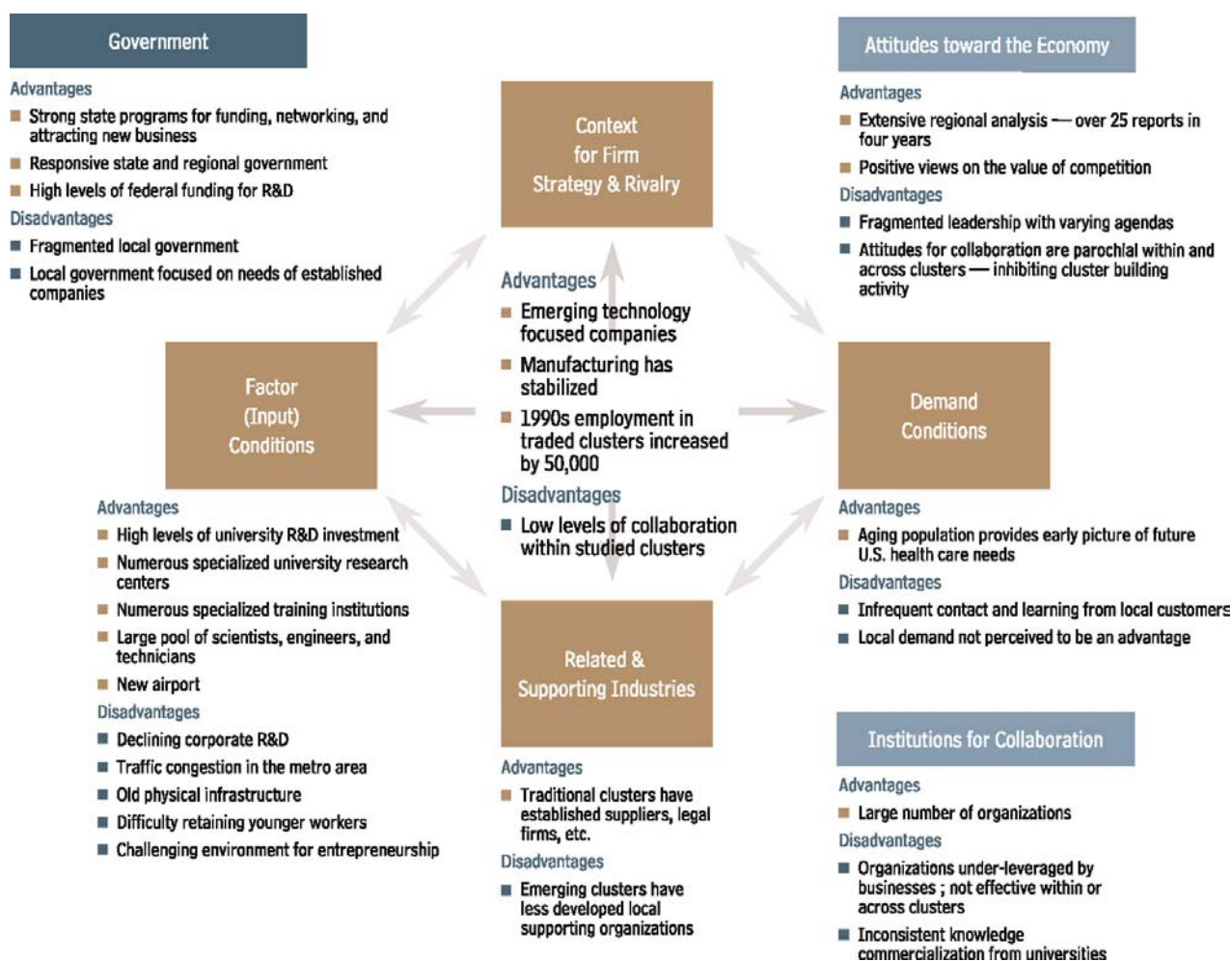


Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

Composition of the Pittsburgh Regional Economy

- **Traded industry versus local industry employment.** Pittsburgh's traded cluster employment as a percent of total employment increased from 30.4% to 31.6% from 1990 to 1999, compared to a decrease for the United States from 34.0% to 31.9%. Twenty-eight of 41 traded clusters have grown faster than the national average during the 1990s in the Pittsburgh economic area. This indicates that although Pittsburgh is not growing jobs in local industries, it is creating them in traded industries.
- **A diversification of the regional economy.** From 1990 to 1999, the five fastest growing clusters were education and knowledge creation, business services, financial services, entertainment,⁴ and medical devices. The three largest job loss clusters include automotive, power transmission and distribution, and metal manufacturing.
- **Strong positions in some of the nation's fastest growing regional clusters.** Two-thirds of the forty traded clusters have grown during the period. The largest clusters in the region are now education and knowledge creation, and business services, which have all grown and the third is the slightly shrinking metal manufacturing cluster.⁵

Exhibit 5: Competitive Position of the Pittsburgh Regional Economy



Source: Clusters of Innovation Initiative Regional Survey™™, Interviews, secondary sources

Innovative Capacity of the Pittsburgh Region

- **Strong local universities.** Pittsburgh has highly regarded educational, medical, and research institutions such as the University of Pittsburgh and Carnegie Mellon University. These are critical resources because universities, in Pittsburgh as well as nationwide, are increasingly a source of new firms and regional economic growth.
- **High levels of federal R&D funding.** The opportunity for universities to spin out new companies is due in part to high levels of federal funding, more than twice the national average.
- **Highly skilled work force.** In addition to the skilled manufacturing workers already in the region, graduates from local colleges and universities provide a steady supply of specially trained scientists and engineers, though this asset is mitigated by the relatively low regional retention rate of graduates.

- **Strong government support.** Regional and state efforts have recently created funding opportunities in biosciences and information technology and have begun to provide forums for business leaders to meet.
- **Good quality of life for families.** Quality of life in Pittsburgh is considered a strength among residents due to low cost of living, relatively low crime rate, and availability of cultural activities.

While fundamentally strong, the Pittsburgh economy faces several challenges that, if unchecked, can undermine the region's historical bases of strength and recent diversified growth.

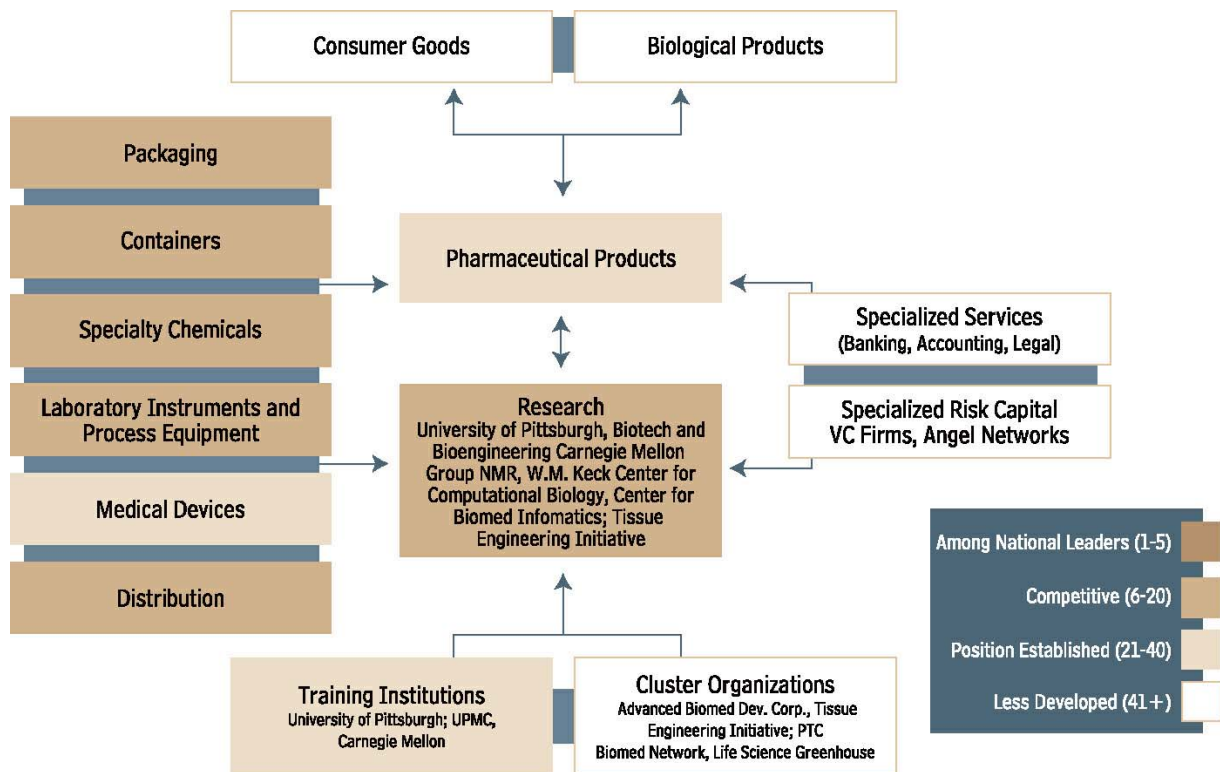
- **Limited cluster depth and collaboration.** Many of Pittsburgh's leaders state that cluster ties and collaboration between firms and cluster organizations are weak. Several organizations attempt to provide an opportunity for cluster participation, but cluster firms do not leverage their potential. Despite the numerous networking events sponsored by the Pittsburgh Technology Council and their large scale participation, there are unmet needs for other types of networking (e.g., peer-to-peer, customer-supplier) and collaboration resulting from this networking seems quite limited.
- **Concerns about the future supply of scientists, engineers, and skilled labor for research and development.** Survey respondents indicate they are concerned that the region will be unable to replenish its current pool of scientists, engineers, and skilled technicians.
- **Need for long-term management and marketing talent.** Survey respondents and interviewees consistently report there is a need to recruit managers and marketers from outside the area with different skills and experiences than available locally.
- **Need for improved linkages between universities and industry.** Local universities do supply firms with skilled employees, but according to interviews and surveys, get decidedly mixed grades for the knowledge commercialization process, which has been described as requiring a better focus for start-up firms. Consequently, the great asset inherent in strong local universities is under-leveraged.
- **Relatively low levels of collaboration.** Attitudes for collaboration appear to be inhibiting the ability of regional firms to foster connectivity among formal and informal collaborative institutions and have inhibited the flow of information, ideas, and resources within and among industry clusters.

FINDINGS FROM THE BIOTECHNOLOGY/PHARMACEUTICAL CLUSTER

Economic Performance

- **Employment.** In 1999, the Pittsburgh MSA had 14,978 biotechnology and pharmaceutical workers, making it the country's 22nd largest cluster (up from the 30th in 1990).
- **Wages.** In 1999, average pay in the Pittsburgh broad⁶ biotech/pharma cluster was \$49,797, which made the cluster the 46th highest paid nationally. Over the 1990 to 1999 period, Pittsburgh's biotech/pharma wage increased at an average annual rate of 6.5%, versus 3.4% for St. Louis and 6.2% for Boston.
- **Patent registration.** In 1998, the Pittsburgh biotech/pharmaceuticals cluster registered 68 patents, well below leading regions such as Boston (635), Philadelphia (379), San Diego (365), and San Jose (363). Pittsburgh's national ranking for patents dropped from 21st to 31st. The patents per employee decreased during that time from 4.9 to 4.7.

Exhibit 6: Composition of the Pittsburgh Biotechnology / Pharmaceutical Cluster



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

Composition

- The strengths of Pittsburgh’s biotech/pharma cluster are in commercial physical research, laboratory instruments and process equipment, packaging, containers, distribution, and specialty chemicals.
- The cluster is relatively weak in the core subclusters of consumer products, biological products, cluster organizations, as well as specialized services and risk capital for biotech start-ups.

Innovative Capacity

Assets

- High levels of R&D investment, particularly at the University of Pittsburgh, where funding surpasses \$200 million
- Numerous specialized research and training institutes
- A large pool of scientists and skilled technicians
- Moderately sophisticated regional purchasers of biotech/pharma products
- High quality (but not abundant) suppliers

Challenges

- Lack of risk funding
- Relatively low levels of competition

- Relatively weak levels of collaboration among firms and organizations in the cluster
- Relatively infrequent contact among buyers and suppliers

FINDINGS FROM THE INFORMATION TECHNOLOGY CLUSTER

Economic Performance

- **Employment.** In 1999 in the Pittsburgh MSA, there were 20,008 employees in the information technology (IT) cluster; 32nd largest out of 318 MSAs. Employment in the cluster has grown 5.2% annually over the 1990 to 1999 period, which was faster than the national rate of 3.6%.
- **Wages.** In 1999, the average wage in the information technology cluster was \$55,345; roughly equal to the national average of \$55,389 for IT workers. This increase from its 1990 level of \$34,159 was an annual growth of 5.5%, versus the nation's rate of 5.3%.
- **Patent registration.** In 1998, local information technology firms generated 72 patents, or 3.6 patents per 10,000 workers. This level is well below the national average of 7.9 patents per 10,000 workers. Pittsburgh's national ranking in patents per worker dropped from 51st to 123rd over the 1990 to 1998 period.

Composition

- The strength of the Pittsburgh IT cluster is in universities and training institutes, instruments, research organizations, software development and information security.
- The cluster is relatively weak in core subclusters such as computers, peripherals, other electronic components, parts, and specialized services (see Exhibit 7 on next page).

Innovative Capacity

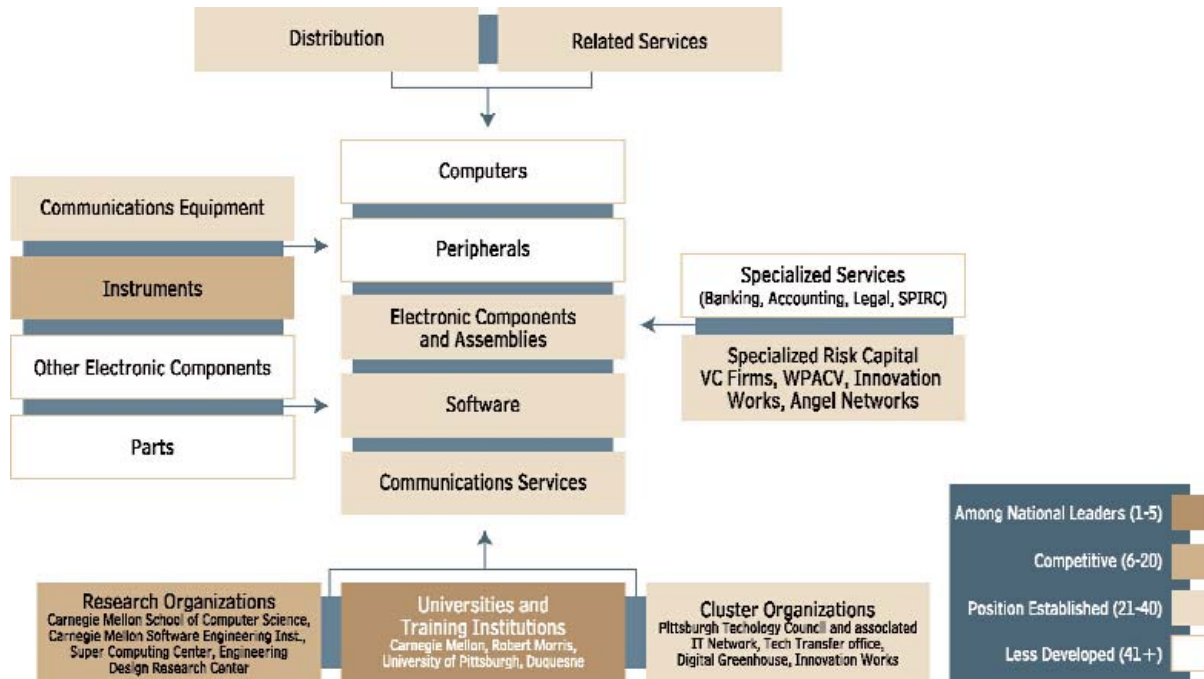
Assets

- Strong R&D, particularly at Carnegie Mellon, with federal funding over \$100 million
- Digital Greenhouse provides an example of a successful organization that provides a collaborative environment for innovation in chip technology with regional partners and regional and external firms
- Strong growth in top five subclusters – more than 20% annually for software
- Local VC firms – supplying a six-fold funding increase to more than \$100 million in 2000
- Regional customers that provide feedback, which spurs innovation

Challenges

- Under-realized potential for technology commercialization from major universities
- Limited supply of managers, marketers, engineers, and skilled labor
- Relatively infrequent collaboration among local firms on the development of new technologies
- Relatively infrequent interaction with local suppliers
- Relatively little help from cluster-specific institutions for collaboration
- Findings from the Production Technology Cluster

Exhibit 7: Composition of the Pittsburgh Information Technology Cluster



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

Economic Performance

- **Employment.** Approximately 36,000 were employed in Pittsburgh’s production technology cluster in 1999. It was ranked eighth nationally in 1999 employment, a slight improvement from tenth in 1990.⁷
- **Wages.** In 1999, the production technology cluster in the Pittsburgh MSA had an average wage of \$42,570 per worker, which ranked 43rd highest nationally. This was a drop from Pittsburgh’s rank of seventh nationally in 1990.
- **Patent registration.** In 1998, Pittsburgh production technology firms and institutions registered 110 patents, representing 1.3% of total U.S. production technology cluster patents (Pittsburgh employs 1.9% of the production technology labor force). Patents per employee decreased, from 3.3 in 1988 to 3.1 in 1998, with a corresponding decrease in rank from 159th to 205th.

Composition

- The largest subclusters in terms of employment are casting and forging (blast furnaces and steel mills), with almost 16,000 employees in 1999. Next come metal work, machine tools, and process equipment. Metal processing, specialized inputs, and specialized services and capital are also competitive nationally. Strong industries in the cluster include dies, tools, jigs and fixtures; metal stampings; air and gas compressors; and general industrial production.

- The cluster is relatively weak in several core subclusters including production machinery, and process equipment subsystems and components; and very weak in transportation equipment, parts, material handling, related machinery, consumer equipment, and construction equipment.

Innovative Capacity

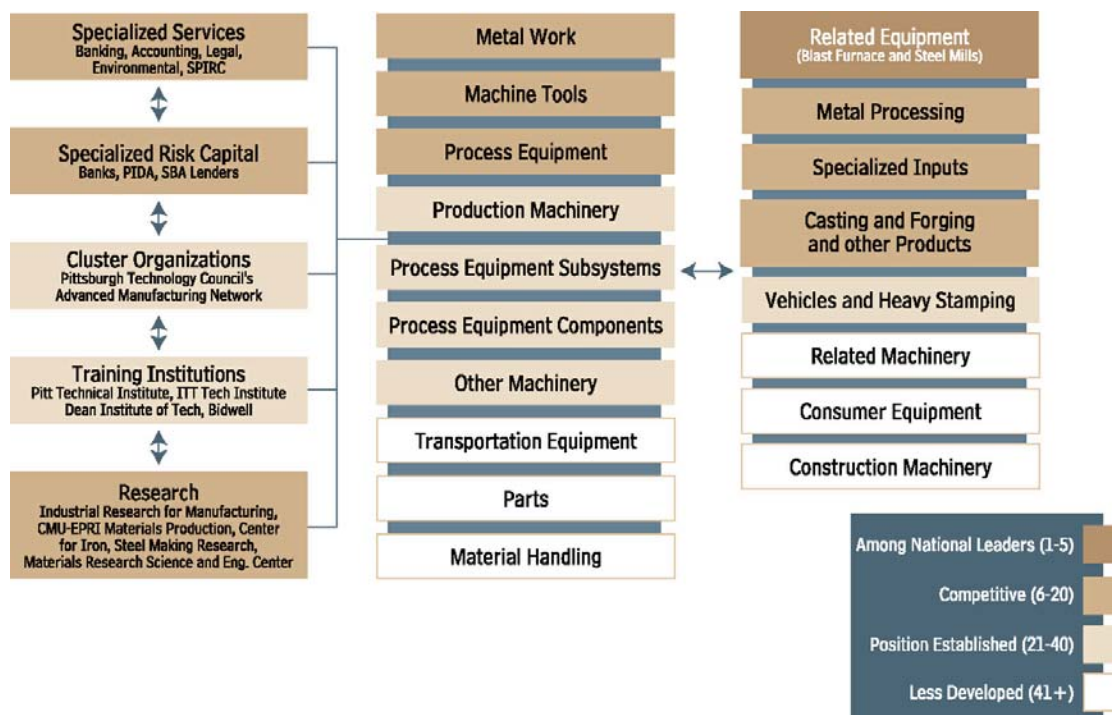
Assets

- Several internationally competitive firms in niche markets remaining after industry shake-out of late 1970s and early 1980s
- Strong R&D, particularly by the larger firms and within robotics
- More than 80 technical schools, with almost 30,000 students mean that the region has an abundant pool of skilled labor

Challenges

- Largest sub-cluster is steel production, which continues to face strong international competition
- Relatively poor knowledge transfer by research centers
- Low current innovation levels as measured by patent production
- Weaker connectivity and cooperation among cluster members

Exhibit 8: Composition of the Pittsburgh Production Technology Cluster



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

LESSONS, CHALLENGES, NEW DIRECTIONS, AND OPPORTUNITIES

Over the past 15 years, Pittsburgh has been on a gradual recovery course from the demise of basic steel, and the regional downsizing of firms such as General Electric, Westinghouse, and Gulf Oil. Pittsburgh's economy has become more diversified, with strong growth in service and knowledge-based industries, as well as continued strength in several manufacturing industries.

During this time, the region's colleges and universities have grown in size and improved in quality into one of the region's leading clusters. The knowledge centers in Pittsburgh have demonstrated their ability to spin out leading technology companies such as Galt Technologies, Lycos and FORE Systems, which acted as galvanizing events in the information technology cluster. These accomplishments have left Pittsburgh with numerous assets with which to develop its economy.

Accomplishments

- Pittsburgh weathered a deep decline in steel and other manufacturing industries in the 1980s.
- Subsequently, the region has established strong positions in advanced manufacturing by creating specialty products.
- Pittsburgh has developed world-class colleges and universities.
- Local entrepreneurs and supporting institutions have demonstrated the ability to create new firms and industries from local knowledge centers.

Assets

These accomplishments have left Pittsburgh with a number of assets:

- High quality of life for families
- Competitive cost position, especially relative to other tech centers
- Experienced manufacturing workforce
- Good workforce training infrastructure
- Broad-based economy with strong manufacturing positions
- Many specialized research centers
- High levels of federal R&D investments at universities
- Positions in fast-growing industry clusters
- Broad array of economic development organizations

Lessons

Pittsburgh'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.

- **Innovation drives prosperity.** Pittsburgh's industrial core in steel and aluminum was driven by advances in new technology. These industries fell behind because of international competition that used new innovations to surpass Pittsburgh's productivity.
- **Local competition drives innovation.** Andrew Carnegie continually pushed for cost cutting and for new ideas. Pittsburgh was a hotbed of mills and innovation before the turn of the century. As U.S. Steel became a holding company of local mills, local competition was reduced and innovation waned.

- **Diversification across several clusters helps to buffer the regional economy.** The lesson is to reinforce and build on emerging and established clusters and not on one or a limited number of clusters. Mechanisms should also be institutionalized that would create opportunities for cross-cluster information sharing.
- **Cluster development is a long-term process.** The basic assets for the information technology and biotech/pharma clusters were developing in Pittsburgh by the 1970s and 1980s, but the clusters did not emerge until the 1990s – and elements of the cluster are still underdeveloped.
- **R&D investment is critical but only a part of innovation.** Pittsburgh is a powerhouse for university research and development (it receives more than twice the national average on a per worker basis), but it requires better commercialization mechanisms.
- **Leadership of a few individuals is vital.** Several interviewees state that the area had an abundance of organizations, but few seem to have the same goal or methodology. There is a need for strong, unified leadership, based in the private sector, to push forward a regional cluster development program.
- **Building strength across elements of the business environment is critical.** Pittsburgh has relatively strong basic and advanced factors for clusters. However, it has poor inter-firm rivalry and collaboration, and demand is mostly found outside the region. Related and supporting industries need to be developed for emerging clusters.

Challenges

Despite its creditable accomplishments, Pittsburgh faces several challenges, which it needs to meet in order to achieve the next level of regional success. Examples of these challenges include the rationalization and utilization of collaborative organizations and improving the start-up environment, which includes a focus on the issue of younger talent migration. The challenges can be classified into the following categories:

Difficulties in workforce retention and recruitment. The leaders and workers of tomorrow, those aged 18-44, continue to leave Pittsburgh. Although high-quality job availability is one of the key criteria, other variables can be effective for retaining and attracting talent. Benchmarks of other regions' amenities can help inform the prioritization process, and leadership must engage all parties, including local municipal leaders, on this issue.

Low levels of innovation. According to a number of metrics, from patent growth to venture capital funding to new establishment formation, Pittsburgh lags behind national averages and benchmark regions in innovation output. This is despite federal research and development funding at twice the national level for Pittsburgh universities. As this study shows, innovation is necessary to boost productivity over the long run, and to support a high and rising standard of living. Pittsburgh will need to reverse these trends.

Challenging environment for start-up and growth companies. There is a developing, but weak network for start-up firms in Pittsburgh. Many economic development groups have begun to discuss and create programs for start-up firms, however, their impact receives mixed reviews. Based on surveys and interviews, several problems facing start-ups are not uncommon. Suggestions for these issues include more support for collaboration with the universities and technology transfer offices.

Underdeveloped clusters. Most firms in clusters do not appear to be leveraging the business community for developing intellectual capital. Sixty-five percent of Pittsburgh respondents state that cluster firms infrequently share knowledge, versus a range of 35% to 49% in other regions. Seventy-two percent

of Pittsburgh respondents state that firm relationships with organizations do little to assist with R&D efforts, versus a range of 42% to 55% in other regions. A project such as the Digital Greenhouse is a good but rare example of how some of these issues can be addressed in Pittsburgh.

Weak collaboration and coordination. A universal theme in interviews and surveys is that Pittsburgh has low levels of collaboration and coordination within and across many groups and organizations. This issue also applies to collaboration between private companies, not just the necessary cooperation between firms and the government or non-profit organizations

- Local government is divided into 130 municipalities, and receives poor marks for collaborating with leaders in the developing industries.
- Although some interviewees state that several organizations, such as the Pittsburgh Technology Council, are effective, our survey finds that most organizations are considered relatively unhelpful compared to their counterparts in other regions. The Pittsburgh Technology Council does frequently provide forums for business leaders to meet,⁸ but information does not appear to pass between firms. As surveys and interviews indicate, the lack of network leveraging could be more likely due to regional attitudes than the efforts of the organizations.
- Numerous interviewees describe the region as “parochial,” “cliquish,” and even “balkanized.” Not since the Pittsburgh renaissance period in the 1950s and 1960s, when organizations, business leaders, and the city government collaborated to revitalize the downtown, has the region experienced a shared vision.

Aging physical infrastructure and logistical concerns could be a constraint on growth. Although leaders in Pittsburgh had the foresight to build a first-class airport, numerous physical infrastructure issues remain. Traffic in and around the metro area is a significant problem, with commute times comparable to Boston and longer than San Jose.

New Directions

Pittsburgh’s historic accomplishments made it a highly innovative and competitive region in the United States. However, competition is dynamic, and to remain competitive Pittsburgh must be dynamic as well. Our analysis indicates that businesses in several Pittsburgh clusters are insular and require a new approach to developing the economy. We identify several themes by which Pittsburgh can transition from a slowly growing economy to a diversified, mature, and strongly performing economy.

From a bifurcated economy to a diversified and integrated economy. Pittsburgh remains a center of manufacturing in America but recently, the high-profile successes have been in new technology industries, and our interviews uncover a sense of rivalry between the “old” and “new” economies. Pittsburgh should strive for a well-diversified economy, having both advanced manufacturing and innovative service and knowledge-based industries.

From basic research to commercialization. Some of Pittsburgh’s most valuable assets are its research universities and institutes, with world-renown centers of research in transplantation, bioscience, computer science, and engineering. These centers spin out many new companies in the region. However, as innovation data, surveys and interviews indicate, more of the basic research must find its way to commercial applications.

From a diversity of groups to a collaborative community. Successful regions tend to have formal collaborative institutions and informal networks that foster interdisciplinary contacts and spur innovation. Pittsburgh has a wide array of these organizations and associations, but interviews and surveys indicate attitudes in Pittsburgh indicate that there is a disinclination to work together effectively in networks. As a local leader stated in an interview, “Pittsburgh is not focused, but it is preoccupied with coming up with a Soviet style plan for development. So we develop five plans each hoping that it’s the grand one.”

Opportunities

Opportunities include unlocking university potential, organizing across clusters, leveraging state and county government’s business focus, and focusing on Pittsburgh’s potential healthcare leadership.

Build global leadership in both advanced manufacturing and new technologies. Pittsburgh retains relatively strong positions in several manufacturing areas. Moreover, through its local universities and research institutions, Pittsburgh can build clusters such as communications equipment, biotech/pharmaceuticals, and information technology.

Better unlock the commercial potential in universities. The universities are a tremendous source of innovation, and opportunities exist to capitalize on relationships, such as the University of Pittsburgh’s affiliation with the healthcare/hospital industry. It is apparent from the surveys and interviews that commercialization of university technology needs to be better supported and improved.

Enhance Pittsburgh’s position as a medical center. The University of Pittsburgh and its affiliated medical center system currently employ over 25,000 people, with more than 3,000 physicians, and serve the second oldest market in the country. This market will forecast the demands of the U.S. population as the baby-boomer generation ages.

Attract non-university research institutions. Pittsburgh needs to reverse the trend in which the number of researchers decreased from 14,500 in 1965 to 8,000 in the mid-1990s. Research centers are the locus of innovation and training, and also help satisfy two of Pittsburgh’s critical needs. First, they can help bridge the gap between basic research and commercial needs of industry. Second, they can help reverse the shrinking population for talented, younger age categories.

Enhance the agenda and action orientation of cluster-specific organizations. One of Pittsburgh’s assets is the large number of institutions for collaboration. However, surveys and interviews indicate they are under-leveraged. Having more effective institutions is important in Pittsburgh to improve interaction among firms, suppliers, and customers.

Organize and pursue growth opportunities at the intersection of clusters. Pittsburgh has a number of relative strengths that offer fertile ground for interdisciplinary collaboration. For example, engineering at Carnegie Mellon and biosciences at the University of Pittsburgh provide the bases for developing tissue engineering. To capture these potential areas of growth, the region needs to build institutions for collaboration that link diverse clusters.

Better leverage of the state government. The state government has been an effective supporter of Pittsburgh’s business environment, with programs such as the Pittsburgh Digital Greenhouse and Innovation Works. The region should seize on this interest and attention to generate further effective state interventions.

Market the region’s opportunities and strengths both inside and outside the region.

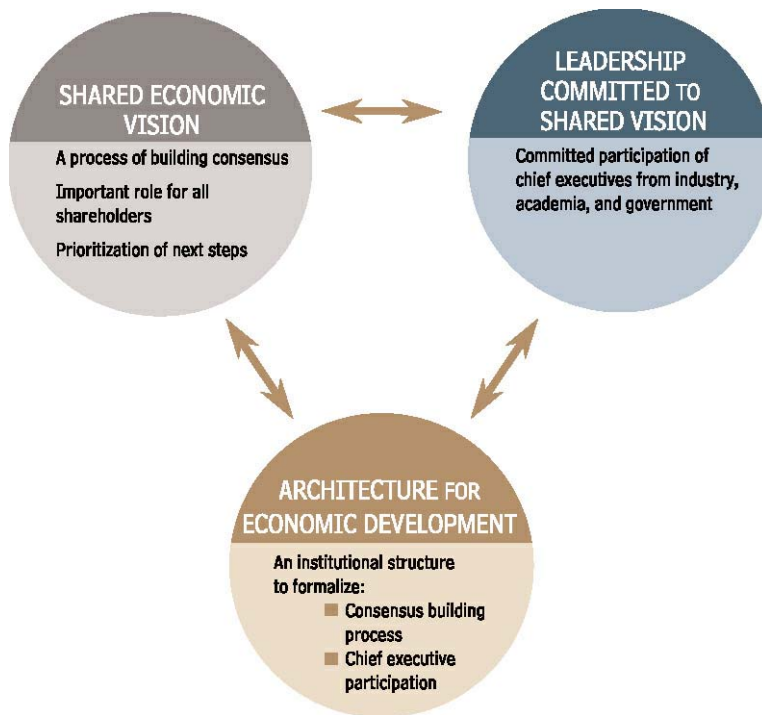
Pittsburgh does not have the critical mass of “high” technology jobs when compared to larger markets such as San Francisco or Boston, nor does it effectively compete with markets with a “buzz,” such as Austin or Seattle. However, the region can focus on attracting this talent to attain a critical mass of attractive jobs and to select infrastructure and cultural improvements that are of highest importance to this group.⁹

Organizing for Action

Pittsburgh has the assets in place to be a highly dynamic and diversified economy. Although it must meet several challenges and seize numerous opportunities to succeed, its development agenda is clear. This agenda is supported by many reports that have been commissioned and compiled since the 1994 report, “The Greater Pittsburgh Region: Working Together to Compete Globally.” Although Pittsburgh has made progress on many of these issues, our quantitative data and survey results indicate that the region lags competitor areas, specifically when it pertains to innovation growth and cluster development.

For an economic development strategy to succeed, leaders in a region need to have a clear agenda and the capabilities to achieve success. Successful regional economies benefit from the contributions of many organizations: companies generate innovations, jobs and wages; universities produce research and trained graduates; governments provide basic education, support workforce training, and build and maintain the physical infrastructure; institutions for collaboration provide information, lobby on behalf of business, help overcome collective action problems among firms, and create networking opportunities. Organizing for action requires a clear agenda concerning these activities and creating the capacity for regions to implement development strategies. This is an imperative for Pittsburgh.

Exhibit 9: Organizing for Action



INTRODUCTION

About the Clusters of Innovation Initiative

Future U.S. competitiveness will hinge not just on policies and investments at the national level, but on the capacity to foster clusters of innovation in regions across the country. The clusters of innovation concept represents a new way of thinking about the economy and is rapidly beginning to take hold as communities across the nation look at the successes of California's Silicon Valley and Massachusetts' Route 128. The nation's ability to produce high-value products and services that support high-wage jobs depends on the strengthening of such regional hubs of innovation.

The objective of the Clusters of Innovation Initiative is to develop a definitive framework for the evaluation cluster of development and innovative performance at the regional level, and share analytic tools, benchmarking results, and lessons learned with key decision makers in every part of the country.

The Initiative — under the leadership of Professor Michael Porter, Harvard University, and Duane Ackerman, Chairman and CEO of BellSouth, and guided by a steering committee of national leaders — is pursuing several avenues of research:

The Cluster Mapping Project at Harvard Business School has created a detailed statistical analysis of county-level business data that defines 40 industry clusters in the U.S. economy and maps regional economies by cluster and constituent industry, together with their employment, average wages, new establishment formation, and patenting.

Concurrently, professionals from the Council on Competitiveness, the Monitor Group, ontheFRONTIER, are studying the performance and composition of regional clusters and selected clusters in regions around the country: Atlanta/Columbus, Georgia; Pittsburgh, Pennsylvania; Research Triangle, North Carolina; San Diego, California; and Wichita, Kansas.

Pittsburgh

This report on Pittsburgh is the third of the five regional reports to be released. Pittsburgh was selected because of its long and rich history in manufacturing, strong research base, midsize market share, and geographic location. As the report will outline, Pittsburgh's economy began with metal manufacturing and related production technology, followed by a wider variety of manufacturing companies. More recently, it is being propelled by the strength and the growth of local universities and research institutions. Pittsburgh has successfully diversified into education, financial and business services, an array of specialized production and manufacturing businesses, transportation and logistics, communication equipment, analytic instruments, medical devices, and nascent information technology and bioscience clusters.

Pittsburgh residents enjoy a good standard of living, with average wages and a cost of living just below U.S. averages. However, lagging job growth, business creation, exports, patenting, venture capital, and IPOs threaten this prosperity. Fortunately, Pittsburgh has strong local universities and research centers, high levels of government R&D funding, a large pool of scientists, engineers, and skilled workers, and many training institutions that can be better leveraged to boost the region's innovation levels. This will require the local leaders to deal with several challenges. According to surveys and interviews of local exec-

utives, there are relatively low levels of interaction and collaboration among firms, universities, research centers, and various local government jurisdictions; and the business environment is difficult for new start-ups (e.g., low levels of venture capital, poor networking, and little access to mentorship and specialized services).

The National Clusters of Innovation Conference

The findings of this report and those of the reports from each of the other regions were presented at a National Clusters of Innovation Conference on December 13, 2001 in Washington, D.C. by the Council on Competitiveness and the National Governors Association. These findings provided the analytical basis for this conference and other initiatives going forward in efforts to create and support high-performing industries and sustain our nation's competitiveness and prosperity.



DETERMINANTS OF REGIONAL PROSPERITY

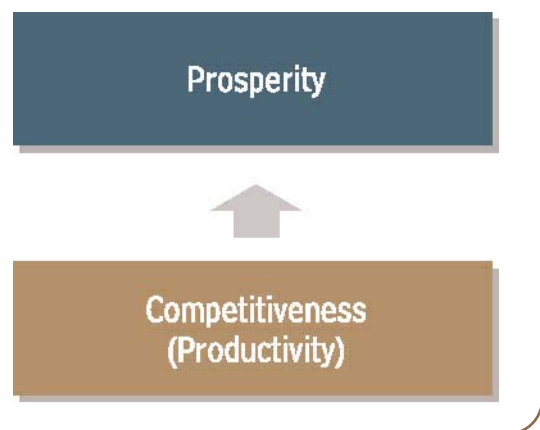
A nation's or region's standard of living is determined by the productivity of its economy. Productivity is measured by the value of goods and services produced per unit of the labor and capital. It sets the wages that can be sustained and the returns earned by investors—the two principal components of a nation's or region's per capita income. (See Exhibit 10).

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 directed to 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 as on 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 10. 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 thanks to 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 brought 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 Japan¹⁰ 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 11).

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 U.S. global preeminence in this industry. The central challenge in enhancing the prosperity of a region is to create the conditions for sustained productivity growth.

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.

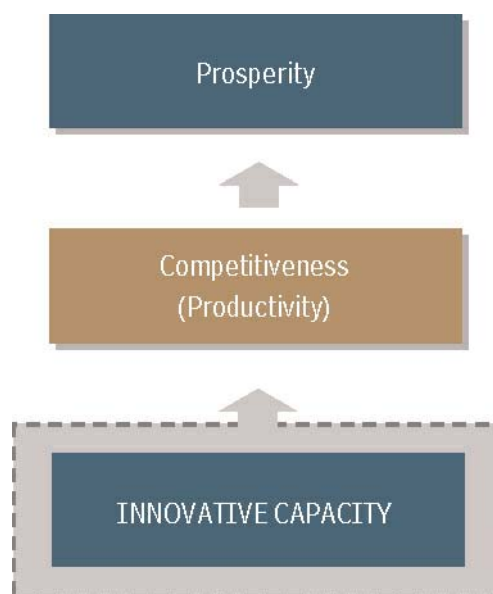
In the modern economy, there are no “low-tech” industries, only low technology companies that fail to incorporate new ideas and methods in their products and services. Innovation can upgrade the sophistication of competition and future productivity throughout a region’s economy, not just in a few “high-tech”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

Exhibit 11: Innovation and the Standard of Living



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 12). Each of them affects the level of productivity that can be achieved as well as the rate of innovation.¹¹

Exhibit 12: Determinants of Regional Productivity

	Common	Cluster-specific
Basic and Specialized Factor Inputs	<ul style="list-style-type: none"> ■ Information and communication infrastructure ■ Skilled workforce ■ Investment in educational capacity ■ Availability of risk capital ■ Quality of life 	<ul style="list-style-type: none"> ■ Presence of specialized research centers ■ Presence of specialized talent base ■ Presence of specialized training and education institutions
Context for Firm Strategy and Rivalry	<ul style="list-style-type: none"> ■ Tax policy (e.g., investment incentives) 	<ul style="list-style-type: none"> ■ Intensity of rivalry among firms in the cluster ■ Degree of cooperation between firms in the cluster
Related and Supporting Industries	<ul style="list-style-type: none"> ■ Regional position in broad based industries such as business services and energy 	<ul style="list-style-type: none"> ■ Extent of related industries inside and outside of the cluster
Sophistication of Demand	<ul style="list-style-type: none"> ■ Overall regional education and per capita income levels 	<ul style="list-style-type: none"> ■ Sophistication of the demand in the region for the clusters' products and services
Government	<ul style="list-style-type: none"> ■ Zoning regulations ■ Coordination between government regional agencies 	<ul style="list-style-type: none"> ■ Cluster-specific regional policies
Institutions of Collaboration	<ul style="list-style-type: none"> ■ Existence of regional institutions of collaboration 	<ul style="list-style-type: none"> ■ Existence of cluster-specific institutions for collaboration
Attitudes toward Value Creation	<ul style="list-style-type: none"> ■ Regional attitudes toward the sources of economic prosperity 	<ul style="list-style-type: none"> ■ Cluster-specific attitudes toward the sources of economic prosperity

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. The quality of more generic and basic factors such as high school graduates or the local transportation system are foundations that every region most 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.

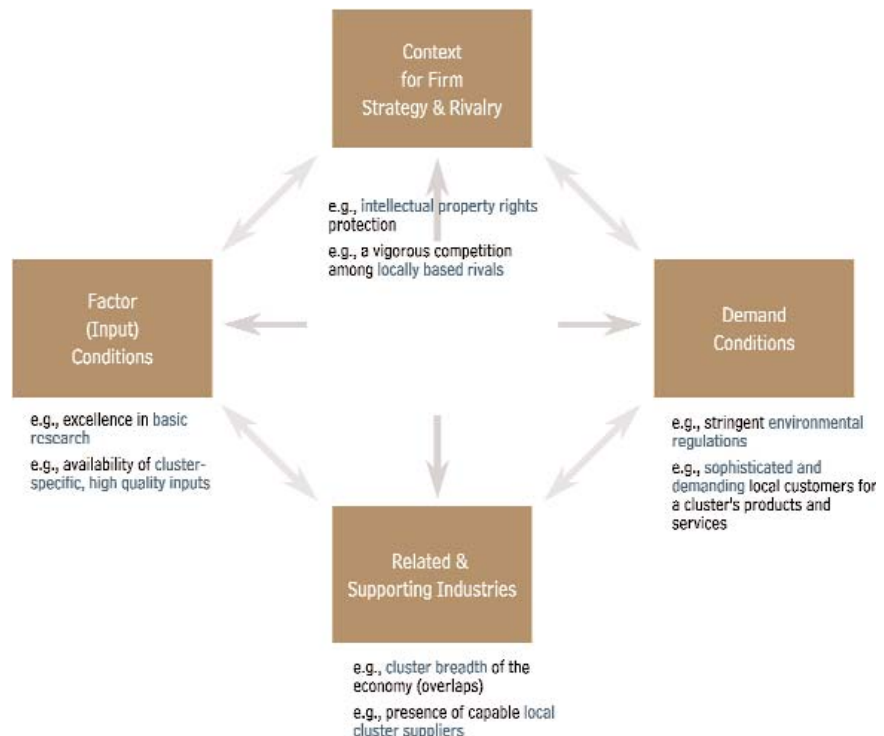
Context for firm strategy and rivalry: The rules, incentives and pressures governing the competition in a region have a fundamental influence on productivity. Policies that encourage investment, protect intellectual property, and open the local market for trade, for example, foster productivity growth and competitiveness. Also exerting a strong influence on productivity is 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 13).

Exhibit 13: Innovation and the Microeconomic Business Environment

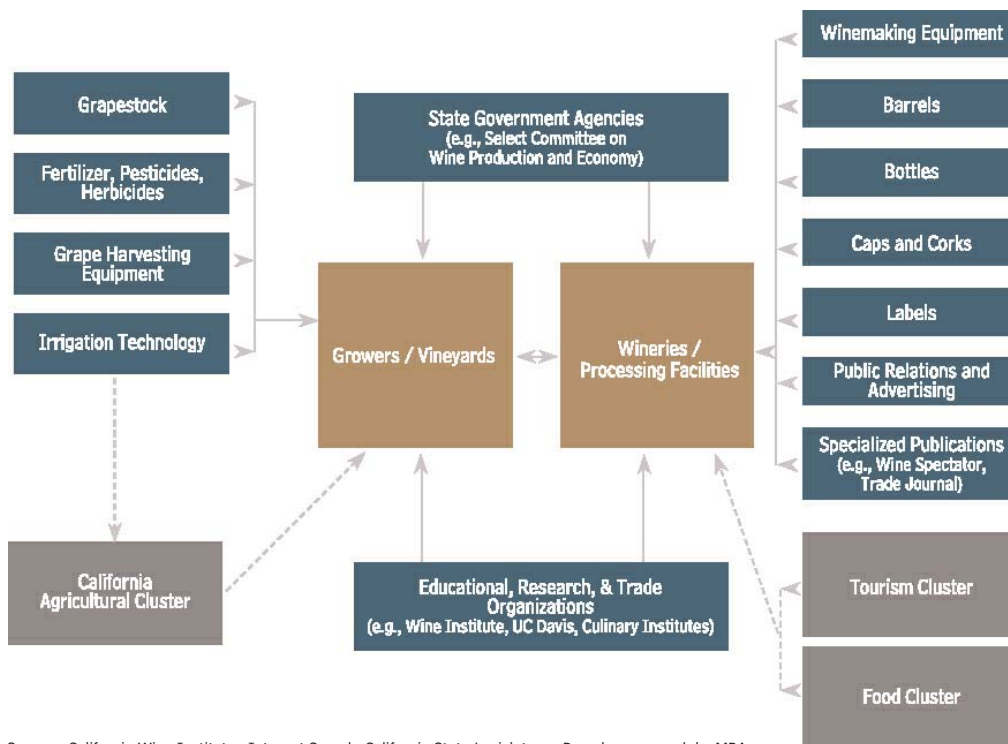


Clusters and Productivity

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 14 below).

Exhibit 14: 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. Shivanda

Clusters enhance competitiveness in three ways.¹² First, they improve productivity because firms have ready, efficient access to specialized suppliers, skills, information, training and technical 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 inter-

nally. 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 well as 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.

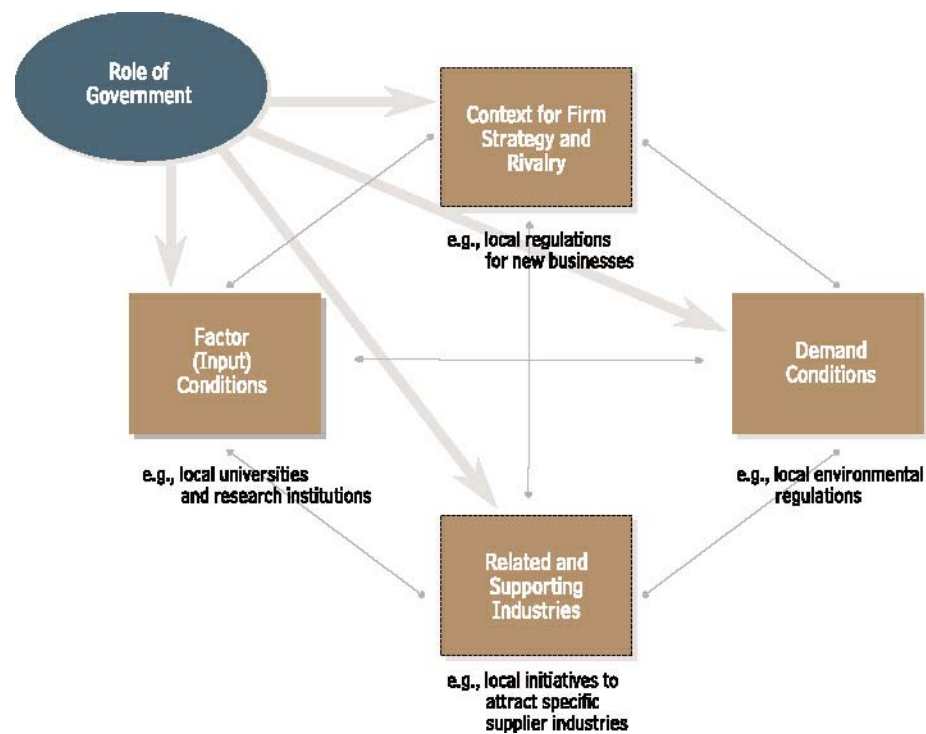
Clusters draw on both general and cluster-specific aspects of the business environment.

Clusters benefit from general national and regional attributes such as intellectual property laws, transportation infrastructure, and 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 15). 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 15: 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, K-12 school districts, 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 (See Exhibit 12).

Institutions for collaboration take various forms (see Exhibit 16). 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 16: Examples of Institutions for Collaboration

General	Cluster-specific
<ul style="list-style-type: none"> ■ Private Sector Chambers of Commerce Professional associations ■ Public sector Economic development agencies ■ Joint private / public Advisory councils Competitiveness councils ■ Informal networks Religious networks School networks 	<ul style="list-style-type: none"> ■ Industry associations ■ Specialized professional associations and societies ■ Alumni groups of core cluster companies ■ Incubators

Economic Attitudes, Values, and Beliefs

A final influence on regional competitiveness and innovative capacity is more intangible. Attitudes, values, and beliefs towards 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 U.S. are beliefs about the importance of entrepreneurship, education, skills acquisition, attitudes towards 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*).¹³

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 that 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 & 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 (see section 6). 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 bene-

fits. 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 that 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 17 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 17. This, in turn, is due in part to the far higher rate of innovation in traded clusters as measured by patents per 10,000 employees.

Exhibit 17: 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 1999	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 (1997) and patent data (1998)
Source: Cluster Mapping Project, Harvard Business School

2 REGIONAL STUDY METHODOLOGY

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).¹⁴ 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 202 executives at companies and institutions throughout the region. Of the total, 63 were companies from the production technology cluster, and 35 were from the information technology cluster, 31 were from the biotechnology/pharmaceutical cluster and 67 were from public sector leaders, regional institutions for collaboration, and other non-cluster organizations (e.g. venture capital firms, banks or universities).

We also conducted in-depth interviews with 51 Pittsburgh leaders. Of these, 24 were cluster representatives and 27 were representatives from academia, government, other clusters, 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, productivity, and exports. To assess potential future competitiveness, we examined measures of innovative output and entrepreneurship including patents, venture capital investments, the prevalence of fast growing companies, and initial public offerings. Wherever possible, we tracked both the level and the growth rate of each performance indicator (see Exhibit 18).

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

Exhibit 18: Economic Performance Indicators

Overall Economy	Innovation Output
<ul style="list-style-type: none"> ■ Employment Growth Rate of employment growth ■ Unemployment Percentage of persons unemployed ■ Wages Payroll per employee ■ Wage Growth Growth rate for payroll per employee ■ Cost of Living Cost of living index ■ Exports Value of manufactured and commodity exports per worker 	<ul style="list-style-type: none"> ■ Patents Number of patents and patents per worker ■ Establishment Formation Growth rate of number of establishments ■ Venture Capital Investments Value of venture capital investment ■ Initial Public Offerings Number of initial public offerings ■ Fast Growth Firms Number of firms on the Inc. 500 list

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).

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.

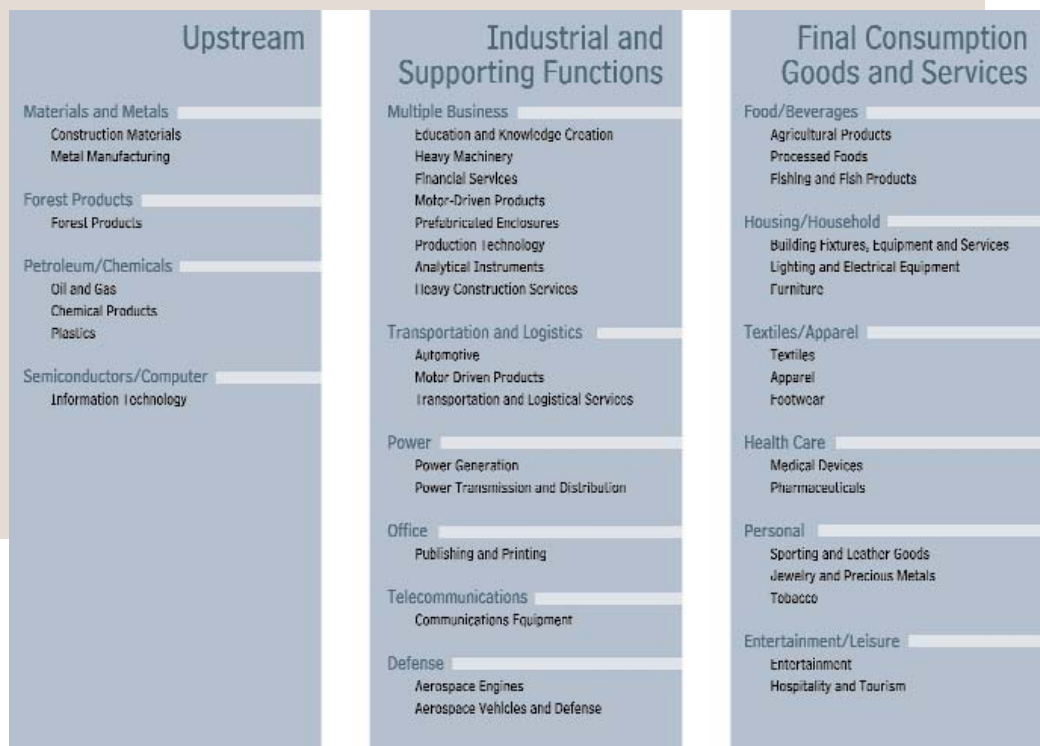
CLUSTER MAPPING PROJECT METHODOLOGY

- The purpose of the Cluster Mapping Project is to assemble a detailed picture of the location and performance of industries 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 U.S. county. In addition, U.S. 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, 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, are evenly distributed, and hence primarily sell locally. Traded industries are those that are concentrated in a subset of geographic areas and sell to other regions and nations.
- Among traded industries, clusters are identified using the correlation of industry employment across geographic areas. The principle is that industries normally located together are those that are linked by some external economies. These industries, then, constitute a cluster.
- Clusters are defined initially using state-level data (n=50). The robustness of cluster composition is verified using Economic Areas as the geographical unit.
- Clusters are constructed using two approaches, which are then reconciled:
 - Select a prominent “core” industry in a field or part of the economy. Calculate the 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 general field and potentially related fields. Those sets of industries with statistically significant and substantial intercorrelations among each other define the cluster.
- In both cases some industries may have spurious correlations to a cluster because of the co-location of several strong clusters in the same geographical area. Spurious correlation is eliminated using Input-Output tables, industry definitions, and industry knowledge.^{A2}
- Note that a given industry can be *part of more than one cluster*. This sometimes reflects 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 other industries. Thus, overlapping clusters are

expected and their overlaps are important economically (see Exhibit 41, Cluster Overlap in the U.S. Economy; Number of Clusters with Common Industries, Section 6, page 56).

- The process of statistically defining cluster boundaries resulted in 41 traded clusters in the U.S. economy. These are shown in the figure below, grouped into broad categories.
- Clusters can be defined using “narrow” or “broad” definitions. We use *narrow cluster definition* to refer to the subset of the industries that are *most correlated* with a given cluster. Analysis using narrow cluster definitions eliminates cluster overlaps. An industry is a narrow industry for only *one* cluster.
- *Broad cluster definition* includes *all* industries with statistically significant locational correlations. This includes industries with stronger locational correlations with another cluster. Analysis using broad cluster definition 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.
- Subclusters are subsets of cluster industries that are the most strongly correlated with each other relative to the rest of the cluster. There are subsets of industries where linkages are particularly strong. We define the subcluster statistically for each cluster. Separate subclusters are defined for narrow and broad cluster definitions. There are 244 subclusters in the 41 traded clusters defined using narrow cluster definition. An additional 245 subclusters arise among industries outside the narrow cluster that fall into the broad cluster definition.
- We also grouped the 241 local industries into clusters primarily using industry knowledge. There are 16 local clusters ranging from local health services and local utilities to local retail clothing and accessories. We did not analyze local clusters extensively in this project, but focused on cross-regional competition. Local clusters are crucial for examining the patterns of location with metropolitan areas.

Exhibit 18: Economic Performance Indicators



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 20 illustrates some of the dimensions of the overall business environment analyzed in each region.

Exhibit 20: Business Environment and Cluster Indicators

	Common	Cluster-specific
Basic and Specialized Factor Inputs	<ul style="list-style-type: none"> ■ Information and communication infrastructure ■ Skilled workforce ■ Investment in educational capacity ■ Availability of risk capital ■ Quality of life 	<ul style="list-style-type: none"> ■ Presence of specialized research centers ■ Presence of specialized talent base ■ Presence of specialized training and education institutions
Context for Firm Strategy and Rivalry	<ul style="list-style-type: none"> ■ Tax policy (e.g., investment incentives) 	<ul style="list-style-type: none"> ■ Intensity of rivalry among firms in the cluster ■ Degree of cooperation between firms in the cluster
Related and Supporting Industries	<ul style="list-style-type: none"> ■ Regional position in broad based industries such as business services and energy 	<ul style="list-style-type: none"> ■ Extent of related industries inside and outside of the cluster
Sophistication of Demand	<ul style="list-style-type: none"> ■ Overall regional education and per capita income levels 	<ul style="list-style-type: none"> ■ Sophistication of the demand in the region for the clusters' products and services
Government	<ul style="list-style-type: none"> ■ Zoning regulations ■ Coordination between government regional agencies 	<ul style="list-style-type: none"> ■ Cluster-specific regional policies
Institutions of Collaboration	<ul style="list-style-type: none"> ■ Existence of regional institutions of collaboration 	<ul style="list-style-type: none"> ■ Existence of cluster-specific institutions for collaboration
Attitudes toward Value Creation	<ul style="list-style-type: none"> ■ Regional attitudes toward the sources of economic prosperity 	<ul style="list-style-type: none"> ■ 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 worthy 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 21 lists the clusters analyzed in each region.

Exhibit 21: Regions, Clusters, and Unique Data

San Diego		Atlanta		Pittsburgh		Wichita		Research Triangle		National Report	
<ul style="list-style-type: none"> Pharmaceuticals / Biotechnology Communications 		<ul style="list-style-type: none"> Financial Services Information Technology Transportation and Logistics 		<ul style="list-style-type: none"> Pharmaceuticals/ Biotechnology Information Technology Production Technology 		<ul style="list-style-type: none"> Plastics Aerospace Vehicles and Defense 		<ul style="list-style-type: none"> Pharmaceuticals/ Biotechnology Communications Shorter Case Studies of Chemicals, Fibers and Plastics 		<ul style="list-style-type: none"> Lessons from Cluster Mapping Project Lessons from Regional Analyses Lessons from Cluster Analyses 	
Interviews	49	Interviews	43	Interviews	51	Interviews	74	Interviews	47	Interviews	264
Surveys	232	Surveys	202	Surveys	202	Surveys	138	Surveys	251	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 U.S. economy were analyzed in at least one region. We also examined the same cluster (e.g., pharmaceuticals/biotechnology in San Diego and Raleigh-Durham) in more than one region to investigate differences across regions in the economic and innovation performance of the cluster.

To assess cluster performance, we compared a cluster (e.g., aerospace vehicles and defense in Wichita) to the national averages and to other benchmark regions (e.g., the aerospace vehicles and defense cluster in St. Louis).

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;
- the issues and opportunities facing particular clusters;
- opportunities for regional growth that are not being pursued.

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3 ASSESSMENT OF THE PITTSBURGH REGIONAL ECONOMY

INTRODUCTION

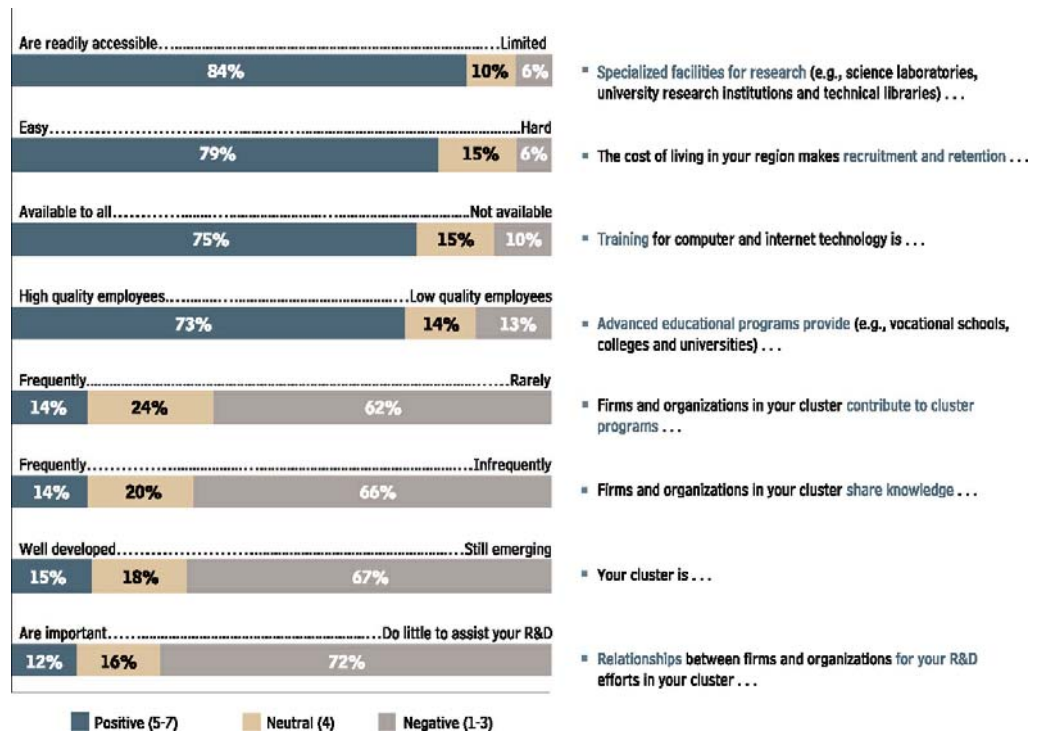
Pittsburgh's economy grew out of a long process, which began with the base of metal manufacturing and related production technology. More recently it is being propelled by the strength and the growth of local universities and the development of their research institutions. Pittsburgh is no longer just a steel and manufacturing town but has diversified into education, financial and business services, an array of specialized production and manufacturing businesses, transportation and logistics, communication equipment, analytic instruments, medical devices, and nascent information technology and bioscience clusters.

Pittsburgh residents enjoy a good standard of living, with average wages and the cost of living just below U.S. averages. A number of indicators, however, suggest this level of prosperity may not last. Job creation is slow, and exports per worker lag national averages. Moreover, innovation output, as measured by patents, patent growth, venture capital, IPOs, and establishment growth, is low.

There are several strengths in the business environment that could help the region boost innovation levels. These include: strong local universities and research centers; high levels of government R&D funding; a large pool of scientists, engineers, and skilled workers; and many training institutions. To leverage these strengths, however, the region must deal with several challenges in the business environment. According to surveys and interviews of local executives, foremost among these are: relatively low levels of interaction and collaboration among firms, universities, research centers, and various local government jurisdictions; and a difficult environment for starting new companies (e.g., low levels of venture capital, poor networking, and little access to mentorship and specialized services). See Exhibit 22 below for a summary of key survey results.

This section assesses the economy of Pittsburgh, which corresponds with the Pittsburgh EA and MSA, as defined by the U.S. Department of Commerce. When we examine the region at the cluster level, we use the economic area, which contains a wider geographic area and is more robust in examining the possibilities for cluster connectivity. We begin with a brief historical perspective, which is essential to understanding Pittsburgh'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 the diamond and cluster theory. The numerous issues and challenges uncovered in the analysis are expanded upon in the final chapter.

Exhibit 22: Regional Factor Inputs and Cluster Linkages; Select Survey Results



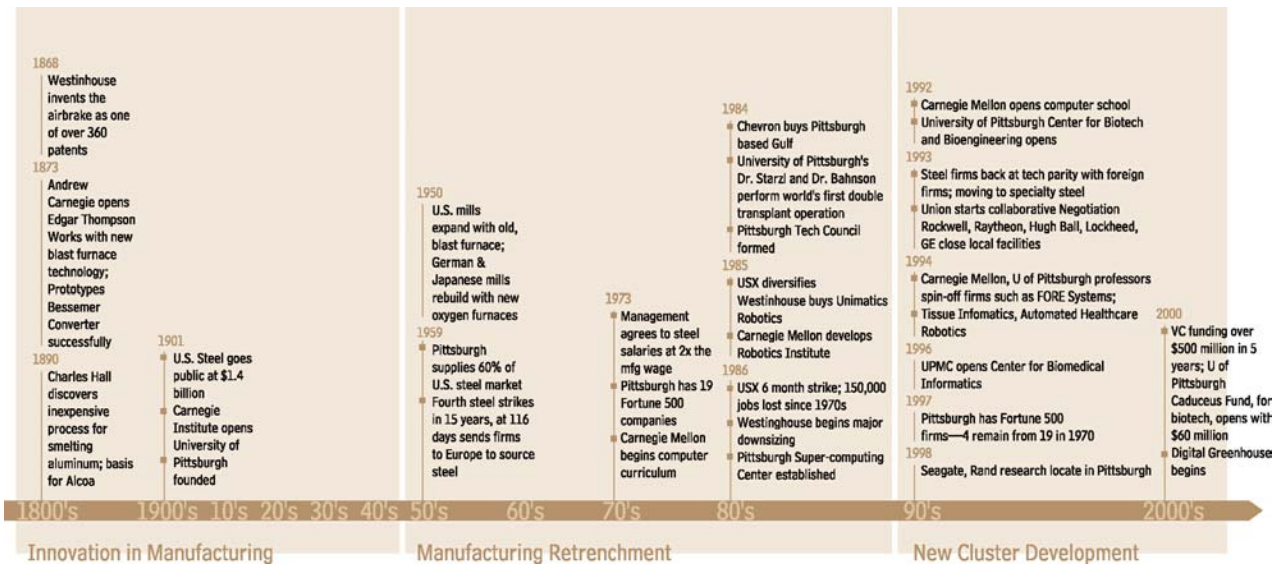
Source: Clusters of Innovation Initiative, Regional Survey

HISTORICAL PERSPECTIVE ON THE PITTSBURGH REGIONAL ECONOMY

Pittsburgh’s economy had been historically well diversified. Railroads delivered materials to Pittsburgh’s factories and carried off finished products to markets in other cities and many industries flourished. The textile industry grew so that by the late 1850s, five large mills employed more than 1,300 people. During the 1860s, Pittsburgh was one of the world’s premier petroleum-refining centers, as crude oil supplanted whale oil for lamps. Following Colonel Drake’s discovery of oil near Titusville, Pennsylvania, Samuel Kier made the world’s first oil refinery operational in downtown Pittsburgh. This led to a boom in northwestern Pennsylvania, as boats full of crude oil headed down the Allegheny River toward Pittsburgh. The refinery period was brief, though, since John D. Rockefeller’s Standard Oil Co. attracted the petroleum shippers to Cleveland, and refineries were later built in Cincinnati and Dayton.

Since then, there have been two main trends to Pittsburgh’s economic development: steel and manufacturing; and education and knowledge creation. The first has roots in the early 1800s, as iron-smelting factories took advantage of the region’s hard-working people, waterway and railroad networks, and abundant coal reserves. By the 1950s, the steel industry’s failure to innovate at the same rate as foreign firms and the relatively high cost of labor laid the groundwork for a major downsizing of Pittsburgh’s steel industry by the mid 1980s. The result was to create unemployment near 13% at its peak in 1983. What was once prime riverfront land became abandoned, contaminated brownfields, with rusted mills.¹⁷ The industry is now focusing more on niche markets, as the number of firms grows, while the number of workers shrinks.

Exhibit 23: Pittsburgh's Economic Development Timeline



Source: Interviews

Meanwhile, knowledge-based industries grew, and university prominence began to create a subculture of entrepreneurship within new industries and a platform for innovation in the region. The education and knowledge creation cluster has grown to be the largest cluster in the region, providing almost 58,700 jobs in 1999, an increase of over 16,000 jobs since 1990. In addition, information technology increased by two-thirds, while biotechnology/pharmaceuticals has increased by almost 40% during that time. Carnegie Mellon University and the University of Pittsburgh, as well as other regional schools, are considered to be the major factor for the region's growth in these industries. The challenge is to continue to generate talent that stays local and to push innovation into the regional economy. Although it is still perceived as an issue, universities are improving at knowledge commercialization.

The following two sections trace the historical evolution in Pittsburgh first of steel and manufacturing, and then of education and knowledge creation.

Steel and Manufacturing

Pittsburgh industries began because of the region's rich seam of bituminous coal, and the rivers that enabled distribution of finished goods. In 1873, Andrew Carnegie opened his first mill, with a steel-producing hearth furnace innovation, in the Edgar Thomson Works at Braddock's Field. As a result of the development of steel and manufacturing firms, the world's first billion-dollar firm, US Steel, went public in Pittsburgh in 1901. Pittsburgh also had its share of inventors, including George Westinghouse (credited with the air brake, alternating current technology, and 360 other patents), and Alcoa's Charles Hall (who invented a more inexpensive method for smelting aluminum).

After contractions in the steel industry due to British competition in the 1920s and then the Great Depression, the region rebounded beginning with World War II, as Pittsburgh supplied 60% of the steel in the United States. During the 1950s and 1960s, the region flourished and Pittsburgh focused on a cultural renaissance, with a partnership between several local business CEOs, foundations, and the City

Government, and spearheaded by the Allegheny Conference. The goal was to revitalize the downtown by building parks, improving the environment, and adding cultural amenities to the region, such as the Heinz Hall for the Performing Arts, which was completed in the 1970s. By 1970, 19 Fortune 500 firms were headquartered in a revitalized Pittsburgh.

However, lack of innovation in the metal manufacturing cluster would soon become a problem in Pittsburgh and all of the United States. Japanese and German firms rebuilt after World War II and introduced basic oxygen and continuous casting technology (which was invented in the United States, but not adopted by major U.S. steel companies).¹⁸ This set the stage for the rapid decline of U.S. steel in the 1970s. When combined with energy shocks, several recessions, and union negotiations that tied worker compensation to the inflation rate, the industry (and Pittsburgh in particular) was about to experience a strong contraction.

Beginning in the late 1970s, almost 150,000 steel manufacturing jobs disappeared from western Pennsylvania in the space of a few years. The MSA's population began to decline – it lost 100,000 residents from 1970 to 1980 (from a base of 2.7 million) and almost 200,000 more throughout the 1980s.¹⁹ During the early 1980s the region experienced double-digit unemployment, peaking at 12.5 % in 1983. Pittsburgh's employment grew from 1988 to 1992 at an annual rate of 1%, and from 1993 to 1997 by 4% annually. During this time, the older industries remained, but with less impact on the region.

The presence of manufacturing and heavy industrial firms also declined precipitously over this time. By the mid 1990s, 15 of Pittsburgh's original 19 Fortune 500 companies had closed, left town, or shrunk out of the top 500. Several steel firms closed, such as Allegheny International, Wheeling-Pittsburgh Steel and National Intergroup. Gulf Oil, Cyclops, H.H. Robertson, Koppers and Joy Manufacturing had been acquired, and H.K. Porter went out of business. Westinghouse began its decline from 19 to three divisions, and a few others, such as L.B. Foster and Copperweld, contracted and fell from the list. In addition, GE cut 20,000 workers in the early 1990s, and Rockwell, Raytheon, Hugh Ball Aerospace and Lockheed closed regional operations because of defense cuts.

Education and Knowledge Creation

Although Pittsburgh has historically been a steel town, it was also home to an important, though much smaller, education and knowledge creation cluster. A key event in the development of the cluster occurred in 1900, when Andrew Carnegie created technical schools for the children of local workers, forming the basis for the Carnegie Technical Institute. The University of Pittsburgh, which formed in 1908, developed an affiliation with Presbyterian Hospital in Oakland to begin the University of Pittsburgh Medical Center (UPMC). The University of Pittsburgh gained national prominence in 1955, when Jonas Salk and a team of University of Pittsburgh researchers developed the polio vaccine. Such events helped to put the University of Pittsburgh on the map as the first enablers for obtaining research funding in the university. Despite Salk's departure for San Diego, the innovation at the university continued.

At the Carnegie Institute, the precursor to Carnegie Mellon University, which formed in 1967, the simple event of bringing the first IBM computer on campus in 1956 provided the genesis for a focus on information technology. This not only set the stage for Carnegie Mellon University to develop a computer curriculum in 1975, and the formation of a computer science school in 1988, but it allowed entrepreneurs in the 1960s, such as Carnegie Institute professor Alfred Kuehn, the capability to meet sophisticated marketing research needs of customers through computer modeling. Several years after Carnegie Tech merged with

the Mellon Institute in 1967, University President Richard Michael Cyert turned Carnegie Mellon University into a research university, which now receives over \$150 million annually.

UPMC gained more prominence in 1984, when Dr. Thomas E. Starzl and Dr. Henry T. Bahnson performed the world's first double transplant operation with the simultaneous replacement of a heart and liver. UPMC has grown into a network of 14 hospitals, 10 affiliate hospitals, 25,000 employees, and 3,000 physicians. The School of Medicine now ranks 14th in the nation for receiving federal funding.

The universities continued to grow with the opening of the supercomputing center by the National Science Foundation in 1986, Carnegie Mellon University's and University of Pittsburgh's Keck Center for advanced training in Computational Biology in 1992, the Center for Biotechnology and Bioengineering in 1993, and the Pittsburgh Tissue Engineering Initiative in 1994 (formal status in 1997). Additionally, Carnegie Mellon University was involved with the Robotics Institute (1986) and the Carnegie Mellon Institute, which helped to set the stage for both high-technology industries and the advancement of high technology in older manufacturing based industries. Duquesne, which began in 1878, has recently been named one of the top ten Catholic schools in the country and is building its research base, as it grew from virtually nothing in the late 1980s to almost \$2 million in federal research funding at the millennium.

Currently, the region has 30 universities and colleges that enroll more than 130,000 students, and another 80 technical schools, with almost 30,000 students. University professors have also spun out information technology and biomedical firms, such as Galt Technologies, Lycos, FORE Systems, Free Markets, InterScope Technologies, Inc. (formerly DFD Information Services, Inc.), and Cellomics. This has resulted in both a high quality employment base and, as of 1998, Pittsburgh having more per capita scientists and engineers than the national average (4.2% versus 3.4%) and more doctoral scientists and engineers per capita than Boston, Los Angeles, or San Francisco.

Exhibit 24: Regional Economic Performance and Innovation Output

Overall Economy	Innovation Output
<ul style="list-style-type: none"> ▪ Employment <i>Annual employment growth rate between 1991 and 2001 in the Pittsburgh MSA 0.3% vs. 1.9% for the U.S.</i> ▪ Unemployment <i>Unemployment rate in the Pittsburgh MSA of 4.3% in 2001 vs. 4.4% for U.S.</i> ▪ Population <i>The population of the Pittsburgh MSA is decreasing at 0.3% annually between 1990 and 1999 vs. 1.0% growth for the U.S.</i> ▪ Wages <i>Average wage in the Pittsburgh MSA of \$32,365 in 1999, vs. \$32,711 for the U.S.; annual growth of wages equaled the U.S. growth rate</i> ▪ Exports <i>Exports per worker in the Pittsburgh MSA were \$3,416 in 1999 vs. \$5,212 for the U.S.</i> 	<ul style="list-style-type: none"> ▪ Patents <i>7.0 patents per 10,000 workers in the Pittsburgh MSA in 1999 vs. 6.3 for the U.S.; 1.3% annual growth in the MSA vs. 4.7% in U.S. from 1990 to 1999</i> ▪ Fast Growth Firms <i>Pittsburgh had 0.8% of the firms on the Inc 500 list between 1991 and 2000 vs. 0.9% of the U.S. employment</i> ▪ Venture Capital Investments <i>VC investments of \$301 per worker in Pittsburgh in 2000 vs. \$387 for the U.S.</i> ▪ Initial Public Offerings <i>Pittsburgh had 0.4 IPOs per 100,000 workers in the past 10 years, well below benchmarked regions</i> ▪ Established Growth <i>The number of establishments in Pittsburgh grew 0.5% annually between 1990 and 1999, vs. 1.4% for the U.S.</i>

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

The Clusters of Today

Today, Pittsburgh's economy has diversified significantly from its days as a steel mill and manufacturing town and is largely the product of the steel/manufacturing trend and the education and knowledge creation trend. It has a major employment base in a variety of sectors including education and knowledge creation, financial services, several retracting manufacturing and production industries, transportation logistics, and communication. During the past ten years, the clusters that have created the most jobs in Pittsburgh are education, business and financial services and entertainment.

REGIONAL ECONOMIC PERFORMANCE

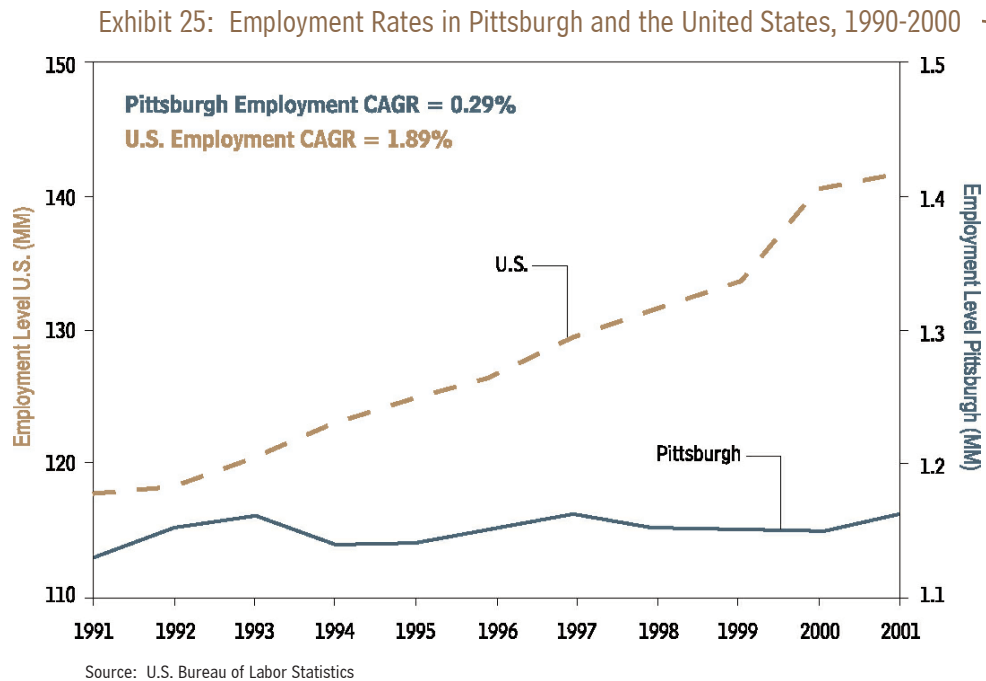
The Pittsburgh economy has a low rate of unemployment, and a solid standard of living. Nevertheless, job creation lags the national rate, as do exports and numerous measures of innovation output. The economy has not rebounded from the job losses in manufacturing, and the trends in performance measures we track indicate no rebound is currently underway.

Indicators of Overall Economic Performance

To assess the overall economic performance of Pittsburgh's regional economy, we compare it to the nation and several benchmark regions in the following metrics: employment, unemployment, average wages, and exports (see Exhibit 24 on previous page).

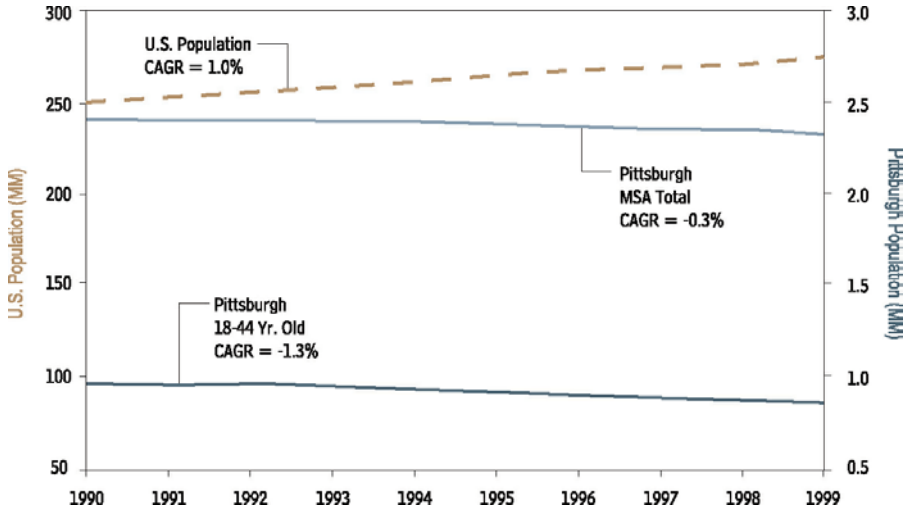
Employment. Over the 1990 to 1999 period, the number of jobs in Pittsburgh increased from 1.13 million to 1.16 million. This rate of 0.3% annual growth fell short of the nation's growth of 1.9% (see Exhibit 25).

Unemployment. The unemployment rate in Pittsburgh, which peaked at almost 13%, in the early eighties, has been mirroring the U.S. unemployment rate over the 1990s. In 2001, it is at 4.3%, almost identical to the U.S. level of 4.4%.



Population. It is important to understand the population growth rate in Pittsburgh, as this affects our interpretation of the low unemployment rate. As Exhibit 26 indicates, Pittsburgh’s population has been shrinking. While the U.S. population grew by 1% annually during the 1990s, Pittsburgh shrank by 0.3%. The loss is even greater among 18-44 year-olds. In this age cohort, Pittsburgh has lost 1.3% over the last 10 years.

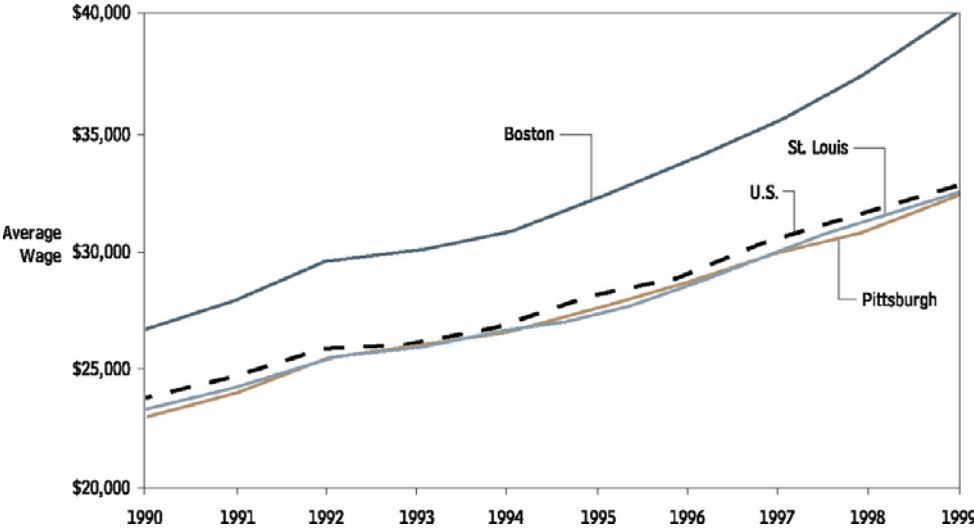
Exhibit 26: Population Growth Rates in Pittsburgh and the United States, 1990-2000



Source: <http://www.consensus.gov/population/estimates/nation/infile1-1.txt>

Average wages. The average wage in Pittsburgh in 1999 was \$32,365, slightly below the national average of \$32,711. Pittsburgh’s 3.8% average wage growth over the period was also slightly below the national growth rate of 4.0% (see Exhibit 27). While Pittsburgh has been relatively close to the national averages, other markets, including the benchmarked Boston market has had very strong growth over the period.

Exhibit 27: Wage Rates in Pittsburgh, Benchmarks and the United States, 1990-1999

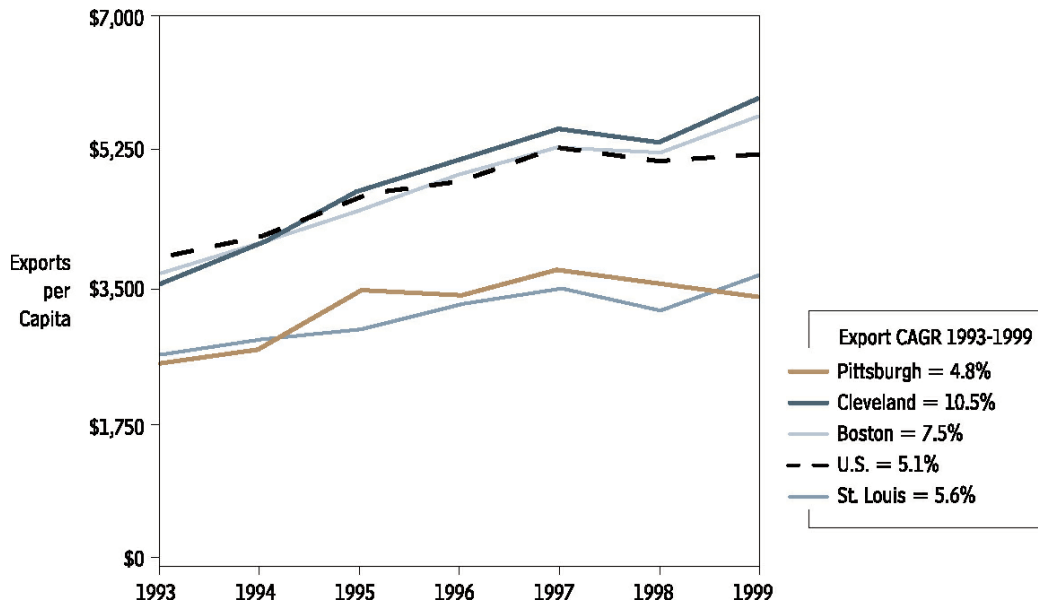


Note: Average wages are nominal
Source: BEA

Cost of living. Although average wages in Pittsburgh lag the nation's, the regional standard of living remains good due to the relatively low cost of living. The region's average cost of housing is slightly below the national average, and significantly below large technology markets such as Boston, Northern Virginia, and San Jose. In the past six years, the average sale price of a 2,200 sq. ft. house in Pittsburgh has risen from \$101,000 to approximately \$155,000, which is still below the national average price of a home of \$164,000. The price in markets with high growth in technology-based jobs, such as San Jose and Boston is \$440,000 and \$631,000 respectively. Pittsburgh executives and community leaders overwhelmingly believed (at 80%, more than any other area in the study) that the cost of living makes recruiting easy.

Exports. Pittsburgh's export value of \$3,416 per worker in 1999 was only 66% of the national average of \$5,212. It was lower than markets such as St. Louis (\$3,696), and Boston (\$5,754). Additionally, from 1993 to 1999, exports grew at an annual rate of 4.8% compared to national export growth of 5.1%, 4.8% for St. Louis, and 7.5% for Boston. (See Exhibit 28).

Exhibit 28: Pittsburgh Region Total Exports versus Benchmarks, 1993-1999



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

Indicators of Innovation Output

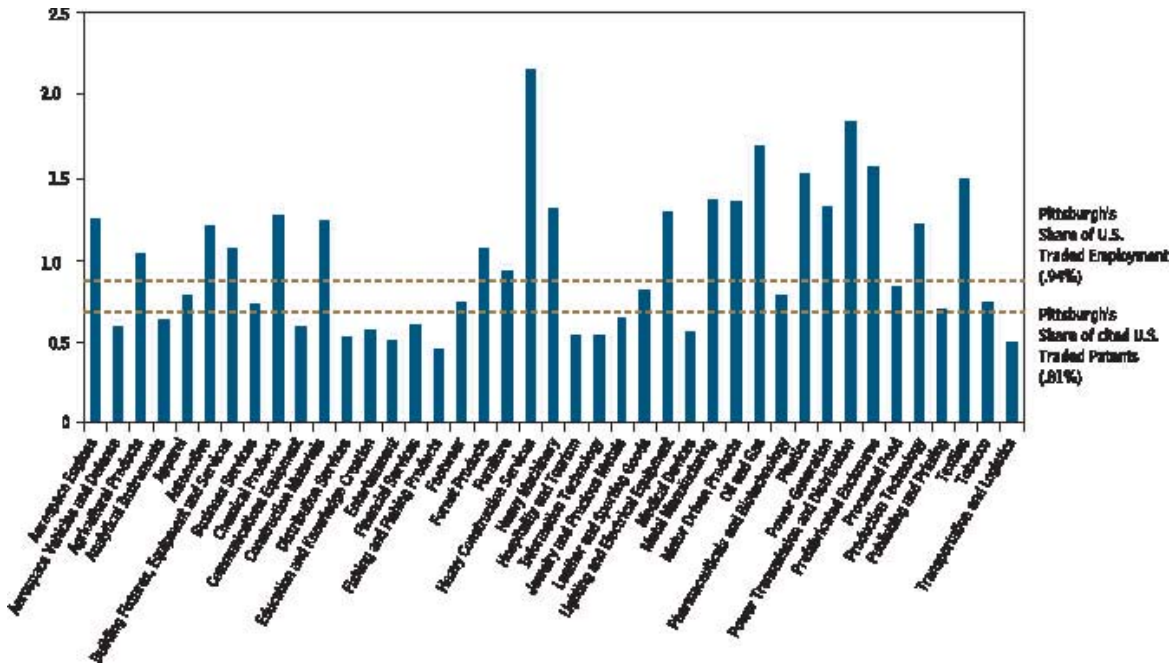
To assess potential future competitiveness, we examined measures of innovative output and entrepreneurship and compared Pittsburgh to both the nation and benchmark regions in the following metrics: patents, the presence of fast growing companies, venture capital investments, initial public offerings, and growth in establishments. Patents are a measure of technical and early stage innovation, whereas venture funding, fast growth firms, and IPOs are a measure of broad types of innovation at successive stages. The findings show that patents per worker in the Pittsburgh region are above the national average, virtually every other measure of innovation lags national averages as well as benchmark regions.

Early state innovation: Patent registration. According to data from the U.S. Department of Commerce, inventors in Pittsburgh registered 809 patents in 1999, ranking it 29th among U.S. metro areas. The growth rate of 1.0% annually from 1990 to 1998, was the lowest among the studied regions, and significantly slower than the U.S. average of 6.4 percent.

Standardized for civilian workforce size, Pittsburgh registered seven patents per 10,000 workers in 1999. This is slightly higher than the national average of 6.3, but well behind other regions such as Boston (20.9) and Austin (22.2). The standardized growth rate for Pittsburgh was 1.3%, through the 1990s, lower than the national rate of 4.7%.

To measure the quality of patents, we look at the number of patents cited in other patent applications, which measures the use of patents. According to this metric, Pittsburgh clusters have a low percentage of quality patents (see Exhibit 29). In 1998, the MSA had 0.99% of the nation’s employment in traded industries, but only has 0.81% of cited patents in traded industries in 1998. So the percentage level of patenting is well below the percentage level of employees in the region. In that same year, Pittsburgh’s patents per worker were above the national average, while its cited patents were below, again indicating that quality patents are below the national average. Construction, oil and gas and power transmission were innovating at levels above the national average. In 1998, patents for information technology, which recently has allowed for software patenting, and education and knowledge creation fell well below the national averages.

Exhibit 29: National Percentage Share of Cited Patents, 1998



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

Later state innovation: VC funding, fast growth firms, IPOs, and new establishment formation. Approximately \$550 million of venture capital was invested in Pittsburgh from 1995 through the first three quarters of 2000. This is roughly \$550 per civilian worker over the period, which falls short of the national average of \$723 over the same time frame. For the year 2000, Pittsburgh had venture capital investments of \$301 per civilian worker, versus \$387 for the United States. Pittsburgh’s annual growth of venture capital investments over this period was 41.9%. This lags the national average of 54.7%, as well as benchmark regions such as Boston (67%) and Austin (80%).

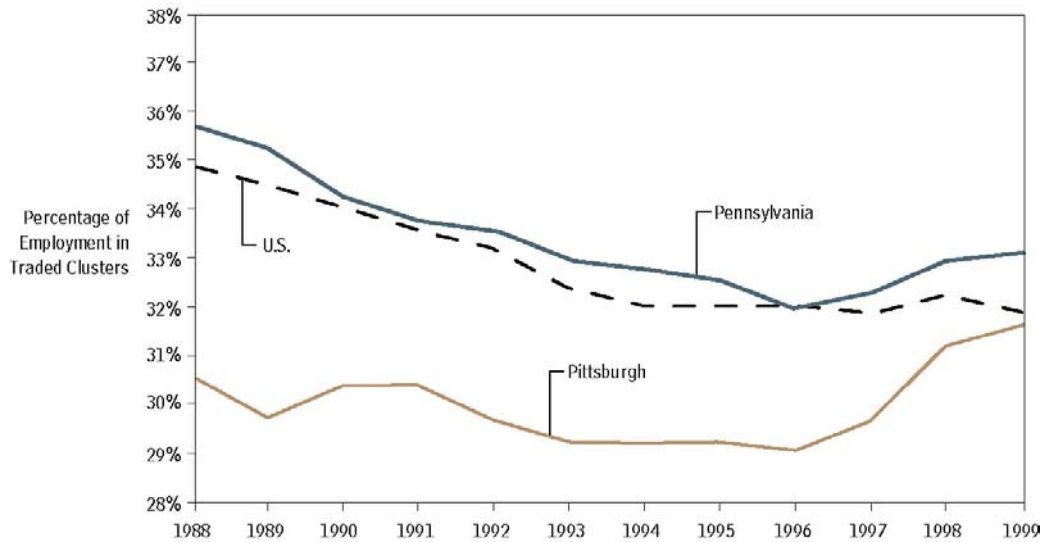
Through the 1990s, Pittsburgh had relatively few fast growing firms for an MSA of its size. From 1991-2000, Pittsburgh had 37 fast growth firms on the Inc. 500 list, or 0.8% of the total (compared to Pittsburgh’s 0.99% of national traded employment).

Pittsburgh has averaged less than three IPOs a year from 1996 to 1999, well below leading regions such as Boston (26 per year), San Jose (25 per year), Washington DC (21), and Austin (7). One of the concerns of the entrepreneurial community in Pittsburgh is obtaining later stage funds with the expertise to go public. Finally, Pittsburgh’s rate of new establishment formation was 0.5% annually from 1990-1999. This was well below the U.S. rate of 1.4% annual growth over the same period.

COMPOSITION OF THE REGIONAL ECONOMY

The percent of Pittsburgh’s work force in traded clusters is slightly below the national average. At the national level, this group of traded cluster workers earns on average almost \$15,000 more per year than local clusters, produce almost 15 times the number of patents and are almost twice as productive as local clusters. In addition, on a tier one basis, Pittsburgh only had seven of its forty traded clusters in a position as both strong and growing.

Exhibit 30: Percentage of Employment in Traded Industries



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

Overall Economy

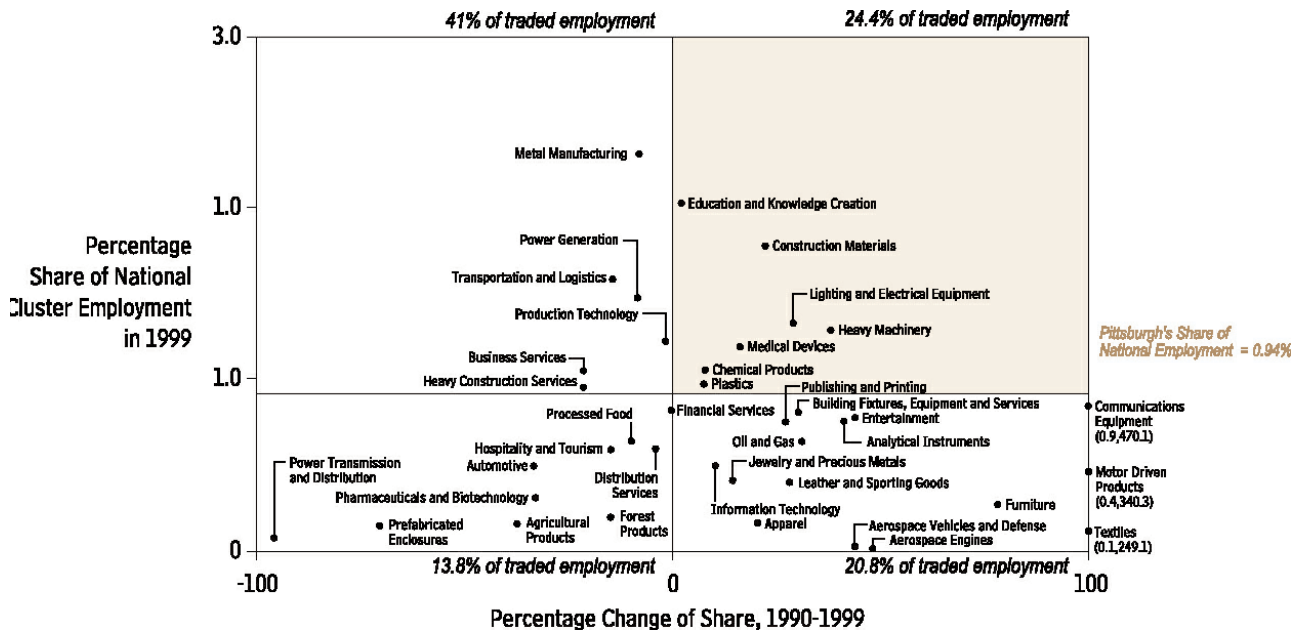
Services are the largest segment in the Pittsburgh economy, accounting for 35.2% of employment at the start of 2001, and having an annual growth rate of 1.9% over the 1990 to 2000 period. Retail trade is the second largest sector at 23.8% of Pittsburgh employment in 2001 with an annual growth rate of 0.6% from 1990 to 1999. Manufacturing is the third largest sector, employing 12.2% of Pittsburgh workers, followed by government at 11.3%.

Pittsburgh had 322,000 employees in traded clusters in 1999 at 31.6% of the workforce, which was just below the U.S. level of 32.1% (see Exhibit 30 on previous page). This percent increased in Pittsburgh from 30.4% in 1990, while the U.S. decreased from 34% at that time.

Clusters

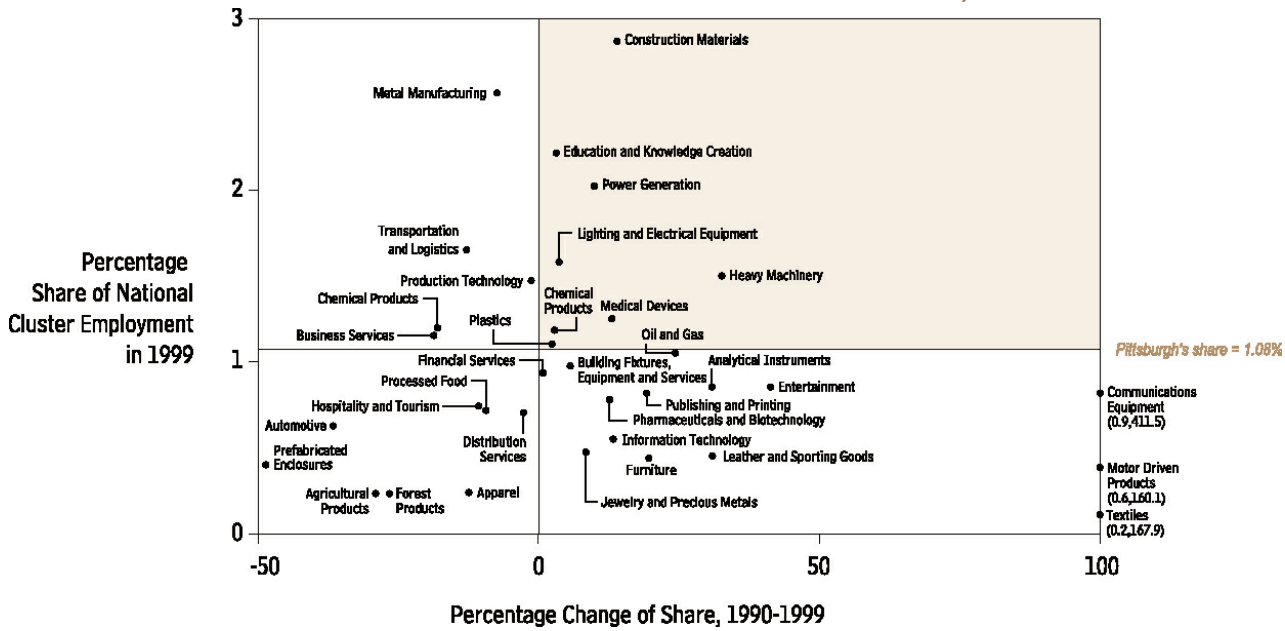
Pittsburgh possesses a relatively broad portfolio of large and growing clusters. Exhibit 31 shows the Pittsburgh MSA's employment share of 41 traded clusters that exist in the United States economy. Pittsburgh's share of national cluster employment is shown on the vertical axis, and its change in share over the 1990 to 1999 period on the horizontal axis. Since Pittsburgh as a region had about 0.94% of total national employment in 1999, this base has been set as the point of intersection on the vertical axis.

Exhibit 31: Specialization of the Pittsburgh MSA; Traded Clusters by Relative Size and Growth Rate, Narrow Cluster Definition



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

Exhibit 32: Specialization of the Pittsburgh EA; Traded Clusters by Relative Size and Growth Rate, Narrow Cluster Definition



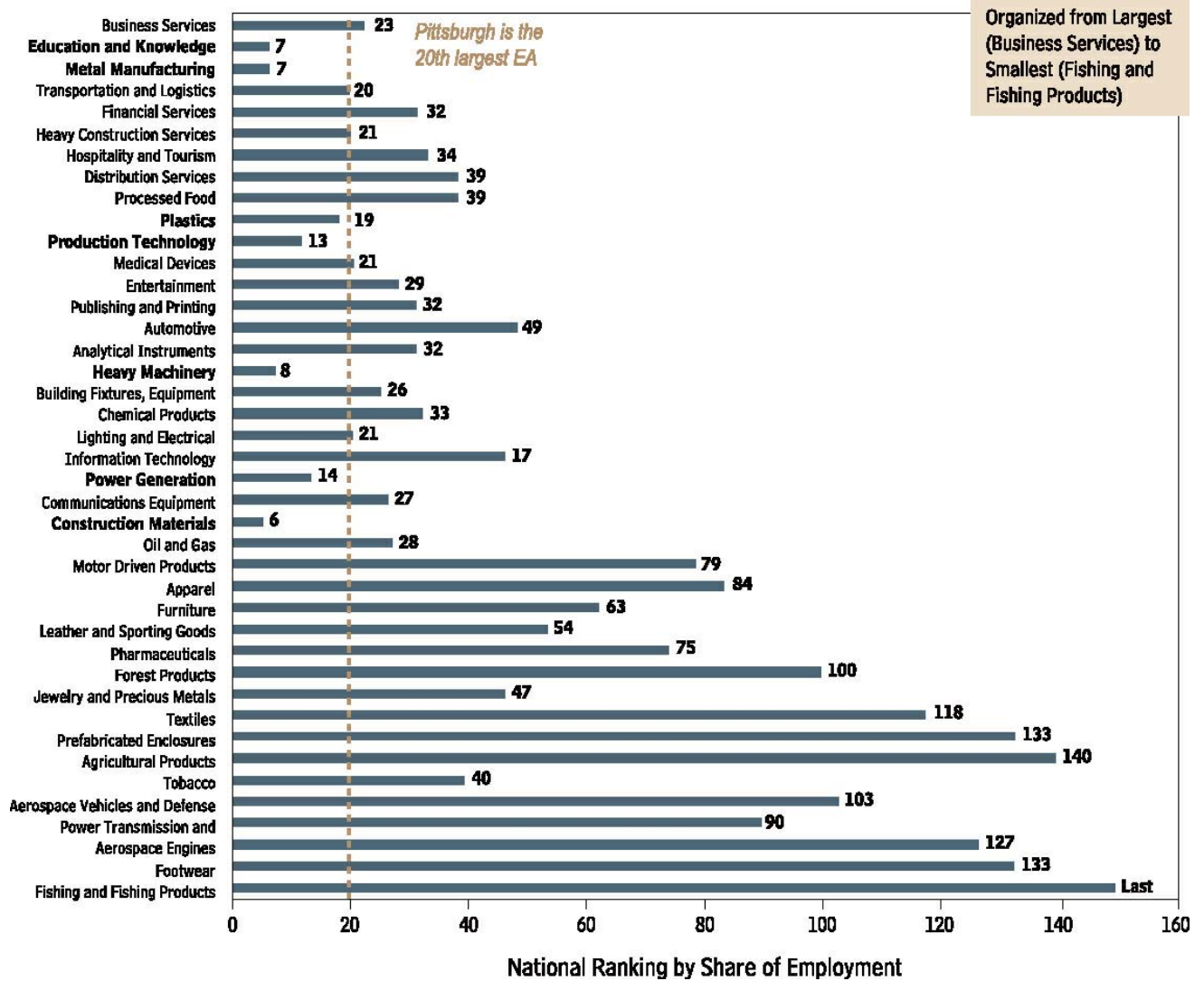
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

Clusters located above the horizontal line have a relatively higher share of national employment than would be expected, based on the region's total share of national jobs; clusters to the right of the vertical line have increased their share of national employment over the 1990 to 1999 period. Therefore, the upper right quadrant represents clusters that have a relatively higher share of national employment and are growing in share of national employment.

Clusters with a relatively high share that have been gaining ground rapidly include construction materials, lighting and electrical equipment, education and knowledge creation, heavy machinery, medical devices, plastics, and chemical products. Clusters with high share that have been losing ground include metal manufacturing, production technology, transportation and logistics, power generation, business services, and heavy construction services.

We also assess the economic composition of the Pittsburgh Economic Area (see Exhibit 32). Using this geographic area, an additional cluster—power generation—falls into the upper right quadrant. The eight clusters for Pittsburgh in this quadrant are just below the U.S. average of 8.5 for an economic area.

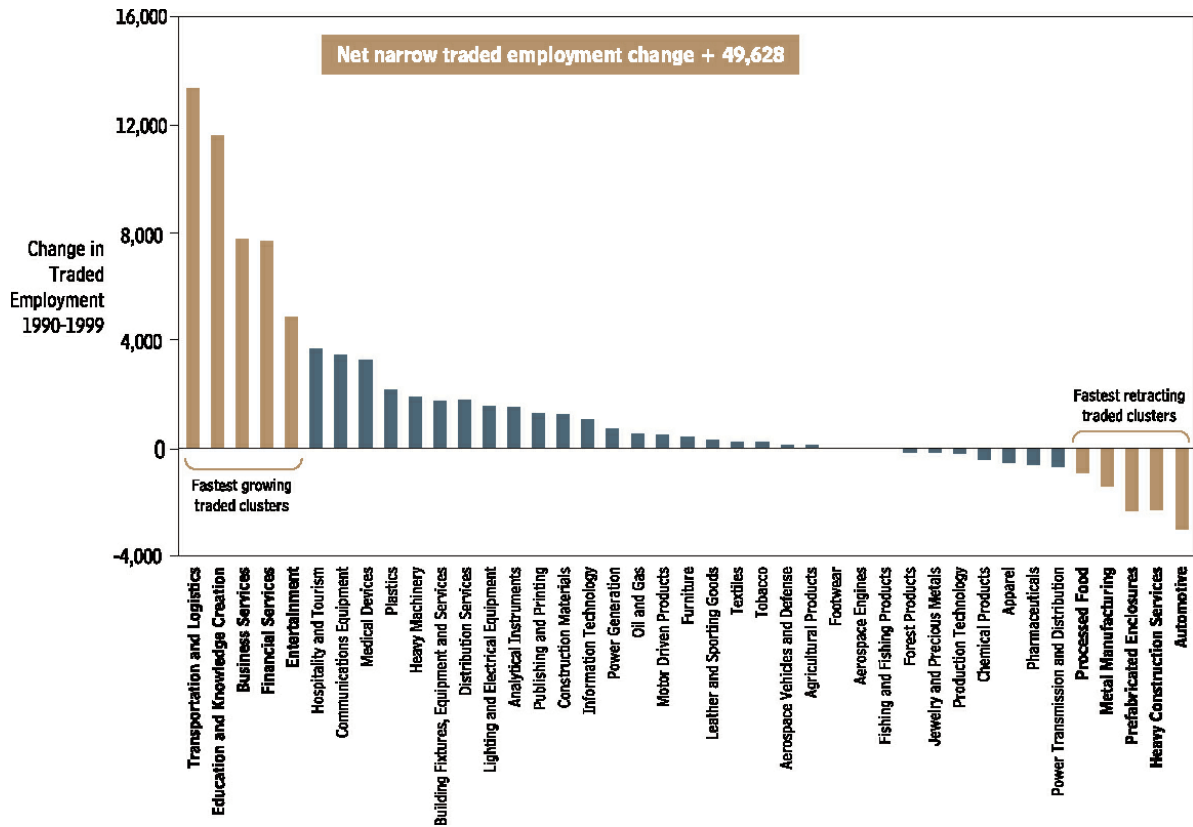
Exhibit 33: Rank of National Employment Share by Cluster (Narrow Classification), Economic Area, 1999



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

As Exhibit 33 shows, four clusters in Pittsburgh are ranked among the top ten in the nation, including construction materials, which is ranked sixth in employment; education and knowledge creation and metal manufacturing, both ranked seventh; and heavy machinery, which is eighth.

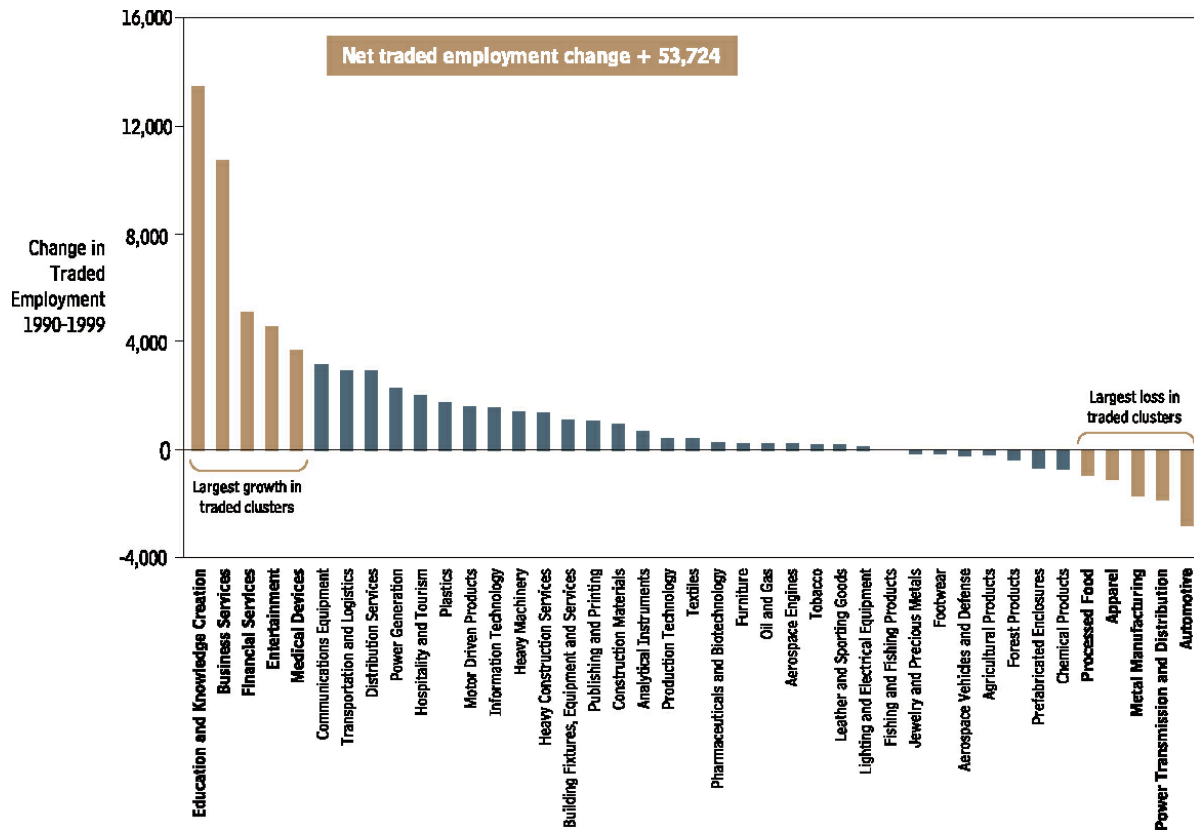
Exhibit 34: MSA Employment Growth and Decline by Cluster (Narrow Classification), 1990-1999



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

Exhibit 34 shows the growth and decline in employment in the Pittsburgh MSA clusters over the 1990 to 1999 period. The net gain in employment in traded industries over the period was more than 49,000 jobs, from a base of just over 270,000. There has been growth in 27 of the region’s 41 traded clusters. The five clusters that added the most jobs over the decade were transportation and logistics, education and knowledge creation, business services, financial services, and entertainment. Clusters often considered to be “high-tech” (e.g., information technology, communications equipment, biotechnology/pharmaceuticals) accounted for a relatively small number of new jobs.

Exhibit 35: EA Employment Growth and Decline by Cluster (Narrow Classification), 1990-1999



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

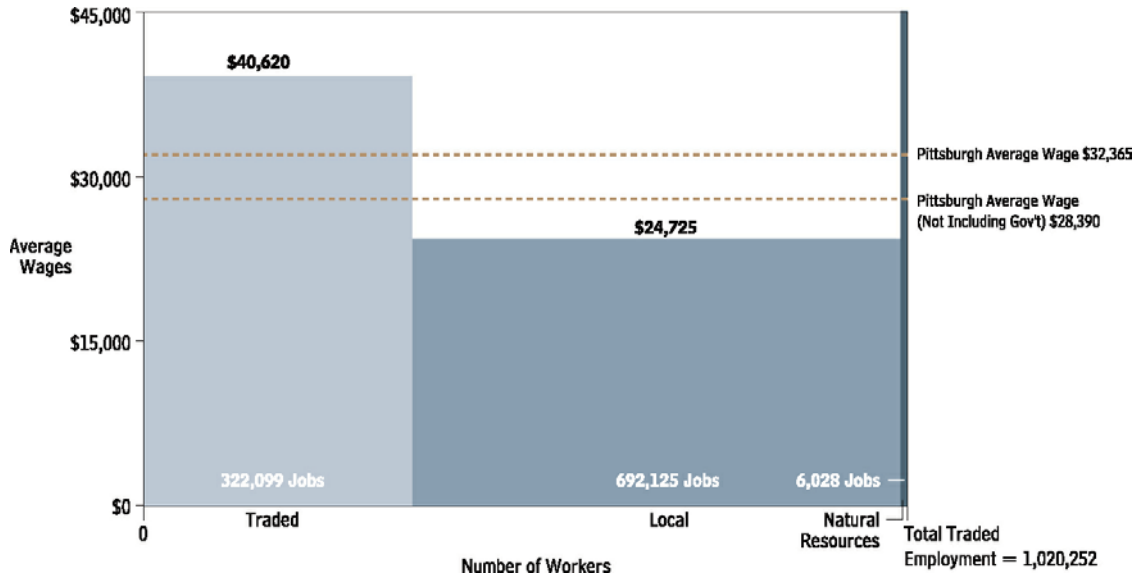
As Exhibit 35 shows, the results are the same when we assess the economic area.

Payroll

As Exhibit 36 indicates, despite only representing 32% of the workforce population, traded clusters represent 43% of the wealth creation in the Pittsburgh Metropolitan Area in 1999.

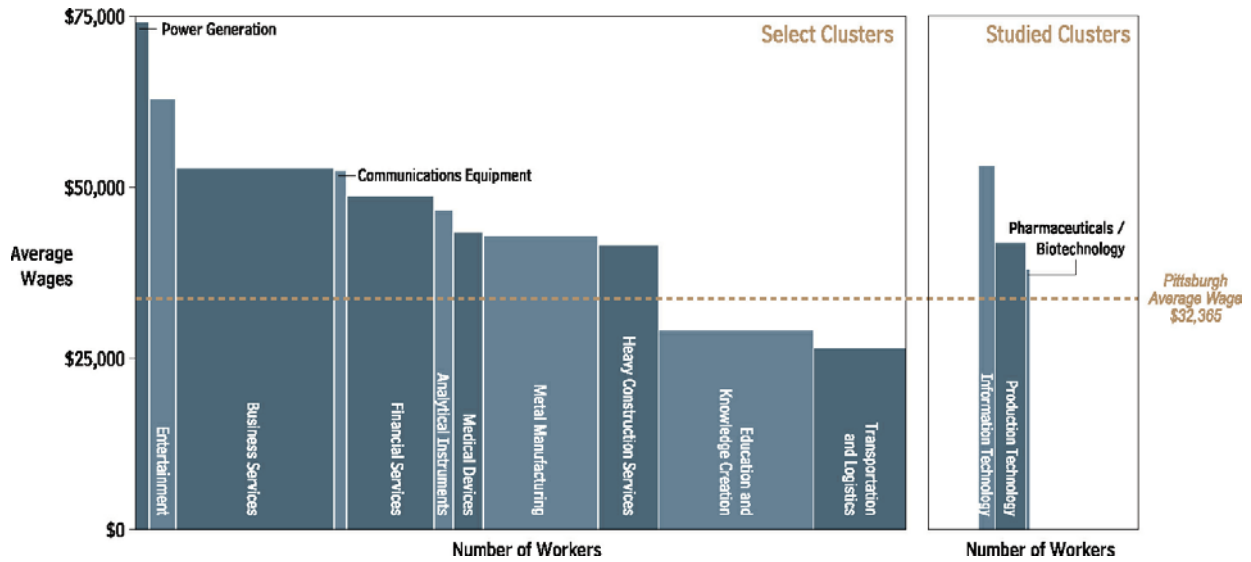
Exhibit 37 shows the economic impact of select clusters in Pittsburgh. The average wage of a cluster is on the vertical axis, and the number of workers on the horizontal. The size of the box, then, represents the amount of total pay a cluster contributes to the regional economy. Although information technology, production technology, and biotech/pharmaceuticals pay relatively high wages, their immediate overall impact is small within the regional economy. Even dramatic growth in these clusters will not significantly increase the overall prosperity of Pittsburgh's citizens in the short run.

Exhibit 36: Composition of Average Wages, Pittsburgh Metropolitan Area, 1999



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

Exhibit 37: Leading Clusters by Payroll, Pittsburgh Metropolitan Area, 1999



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

Exhibit 38: Employment, Wage and Patent Metrics of Pittsburgh’s 20 Largest Clusters by Economic Area (Narrow Cluster Classification)

Pittsburgh Clusters by Employment	Employment 1999	Growth Rate in Employment 1990-1999	Wages Indexed to Nation, 1999	Growth Rate of Average Wage Index, 1990-1999	Employee Indexed to Nation, 1998
Business Services	48,699	2.8	99.1	-0.6	0.5
Education and Knowledge Creatoin	47,779	3.7	95.6	1.4	0.3
Metal Manufacturing	35,733	-0.5	115.4	-1.6	0.7
Financial Services	27,140	2.3	71.1	-3.0	0.5
Transportation and Logistics	25,799	1.3	73.6	3.2	0.2
Heavy Construction Services	21,481	0.7	111.4	1.4	1.6
Hospitality and Tourism	17,997	1.3	83.4	0.2	0.7
Distribution Services	12,891	2.9	94.0	-1.6	0.8
Production Technology	9,955	0.5	108.1	1.3	1.0
Processed Food	9,774	-1.0	84.8	1.1	1.3
Plastics	9,475	2.2	118.6	1.9	1.7
Medical Devices	8,384	6.5	99.0	0.5	0.6
Entertainment	8,340	9.1	163.8	2.7	0.7
Automotive	7,938	-3.3	72.4	-1.5	1.7
Publishing and Printing	7,817	1.6	101.3	0.9	0.9
Building Fixtures, Equipment, and Services	6,321	2.1	98.0	-0.7	1.1
Heavy Machinery	6,248	2.9	81.6	-0.8	0.9
Analytical Instruments	6,246	1.2	95.9	1.7	1.0
Construction Materials	5,820	2.0	100.0	8.8	0.4
Power Generation	5,420	6.3	131.0		0.6
Number Outperforming the National Average			7.0	12.0	5.0

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

Exhibit 38 shows employment, wage, and patent data for the 20 largest clusters in the Pittsburgh economic area. Wage and patent measures are indexed to the national average. An average wage score of 100 (e.g., construction materials) means Pittsburgh’s cluster pays wages right at the national average; a higher score means the Pittsburgh’s cluster pays above average. A positive value for growth in wages indicates that Pittsburgh’s cluster is increasing average wages faster than the national average for that cluster. A patents per worker score of 1.0 (e.g., production technology) indicates Pittsburgh’s cluster is on par with the national average for that cluster.

Average wages and wage growth are relatively strong. Seven clusters pay wages above the national average for that cluster, and another seven are just below the national average (as is Pittsburgh’s cost of living). Wages are growing faster than the national average in 12 clusters. In patents per employee, however, only 5 out of 20 clusters exceed the national average (heavy construction services, processed food, plastics, automotive, and building fixtures, equipment, and services), and these are in traditional manufacturing clusters.

Industries in Pittsburgh

Exhibit 39 shows the ten industries in the Pittsburgh region that added the most jobs to the economy over the 1990 to 1999 period. Of the ten, only one is a manufacturing industry — railroad equipment—while the other nine are service or knowledge creation industries. These fast-growth industries have played a key role in the growth of such clusters as financial services, transportation, communications, education and knowledge creation, analytical instruments, and information technology. The industry perspective also allows a deeper understanding of what is driving the changes in the clusters.

Examining the declining industries in the region sees the same shift from basic manufacturing toward specialized manufacturing, services, and knowledge creation. Of the ten industries that lost the most jobs (Exhibit 40), seven are in manufacturing, and three are in service industries. The two industries with the largest job losses are blast furnaces and steel mills, and life insurance, which when combined lost almost 5,000 jobs in the region during that period.

Exhibit 39: Ten Pittsburgh Industries with the Largest Employment Growth, 1990 to 1999

Industry	Colleges and Universities	Hospital and Medical Service Plans	Foreign Bank and Branches and Agencies	Holding Offices	Computer Integrated Systems Design	Operative Builders	Air Transportation, Scheduled	Railroad Equipment	Prepackaged Software	Plastics Products, n.e.c.
Clusters in which Industry Features	<ul style="list-style-type: none"> Education and Knowledge Creation 	<ul style="list-style-type: none"> Financial Services Medical Devices 	<ul style="list-style-type: none"> Financial Services 	<ul style="list-style-type: none"> Financial Services 	<ul style="list-style-type: none"> Business Services 	<ul style="list-style-type: none"> Heavy Construction Services 	<ul style="list-style-type: none"> Transportation and Logistics 	<ul style="list-style-type: none"> Heavy Machinery Prefabricated Enclosures 	<ul style="list-style-type: none"> Aerospace Vehicles and Defense Analytical Instruments Communication and Equipment Education and Knowledge Creation Financial Services Information Technology Medical Devices Publishing and Printing Transportation and Logistics 	<ul style="list-style-type: none"> Plastics
Change in Employment 1990 to 1999	7,616	5,027	3,216	2,700	2,311	2,283	2,204	2,191	2,050	2,004

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

Exhibit 40: Ten Pittsburgh Industries with the Largest Employment Decline, 1990 to 1999

Industry	Pumps and Pumping Equipment	Automotive Stampings	Canned Specialties	Products of Purchased Glass	Services, n.e.c.	Transformers, except Electronic	Savings Institutions	Surgical Appliances and Supplies	Life Insurance	Blast Furnaces and Steel Mills
Clusters in which Industry Features	<ul style="list-style-type: none"> Fixtures, Equipment and Services Metal Manufacturing 	<ul style="list-style-type: none"> Automotive Production Technology 	<ul style="list-style-type: none"> Agricultural Products 	<ul style="list-style-type: none"> Automotive 	<ul style="list-style-type: none"> Business Services 	<ul style="list-style-type: none"> Transmission and Distribution 	<ul style="list-style-type: none"> Financial Services 	<ul style="list-style-type: none"> Analytical Instruments Medical Devices 	<ul style="list-style-type: none"> Financial Services 	<ul style="list-style-type: none"> Metal Manufacturing Production Technology
Change in Employment 1990 to 1999	-950	-1,000	-1,008	-1,387	-1,409	-1,750	-1,785	-1,926	-2,324	-2,460

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

REGIONAL INNOVATIVE CAPACITY

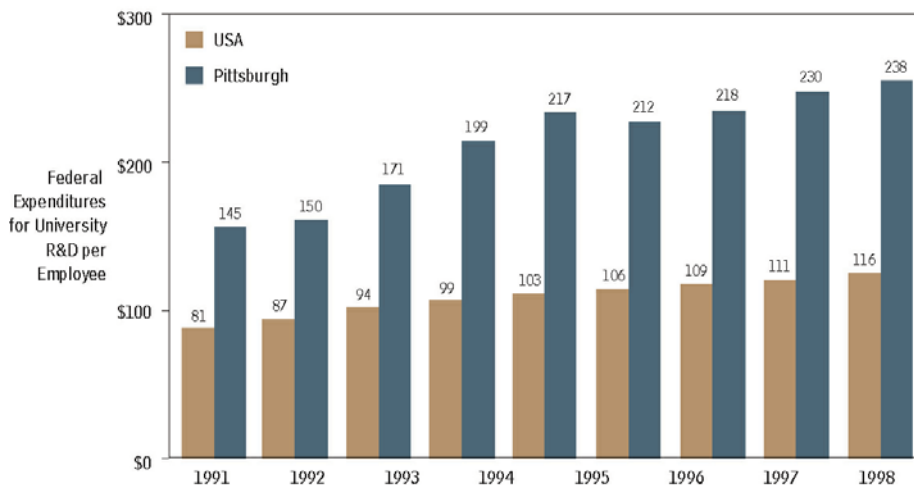
Although Pittsburgh's economy provides a good standard of living today, lagging innovation output raises concerns about the prosperity in the future. Our assessment of regional composition shows that innovation must occur across a broad range of clusters. The economic impact of clusters such as information technology, communications equipment, biotechnology, and medical devices is too small to raise the overall standard of living in the region. A healthy business environment for innovation gives firms the capacity to innovate, raise their productivity, and generate rising levels of wealth. This does not suggest that current regional activities in sectors such as information technology or biotechnology is inappropriate, only that the issues of innovation and productivity must include a focus on other more broadly based sectors as well.

At the regional level, the most important diamond factors are 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. Pittsburgh performs well in terms of factor inputs, such as research and development, and workforce development in the universities. Factors having little positive effect on cluster effectiveness have been the strength of cluster ties, the supply of risk capital, newly developing formal and informal institutions for collaboration, the scarcity of management and marketing expertise and the skilled workforce base, and the efficiency of knowledge commercialization from local universities.

Basic and Specialized Factor Inputs

Investment in research and development. Pittsburgh has an impressive array of research facilities, with almost half of local researchers based in universities. In 2000, according to the local universities, the University of Pittsburgh and Carnegie Mellon received over \$300 million and \$170 million, respectively,

Exhibit 41: Federal Funding for University R&D per Worker, 1990-1998³⁹



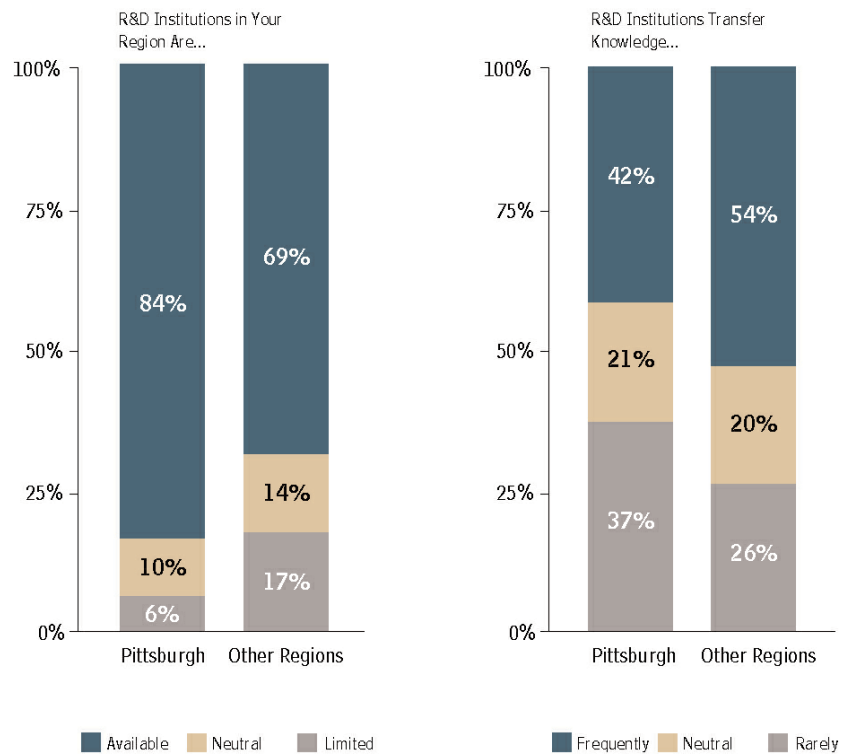
Source: WebCASPAR Database; U.S. Bureau of Labor Statistics

in total research funding.³⁸ According to Department of Education’s WebCASPAR database, regional universities received \$265 million in federal funding in 1998. According to this source, the region’s growth rate was 6.9% versus the nation’s 6.3% growth rate at that time. Standardizing by the number of workers, Pittsburgh consistently receives more than twice the national average of R&D investment per worker (Exhibit 41 on previous page).

Each university has developed numerous specialized research and development centers. For instance, both university researchers and private-sector partners affiliated with the university use the Supercomputer Center to speed massive research tasks and to test new products in the software, communications, and biotechnology industries. Several centers, such as the W.M. Keck Center for Advanced Training in Computational Biology, are collaborations between several universities. Others are collaborations between universities and the private sector such as Seagate and Carnegie Mellon University.

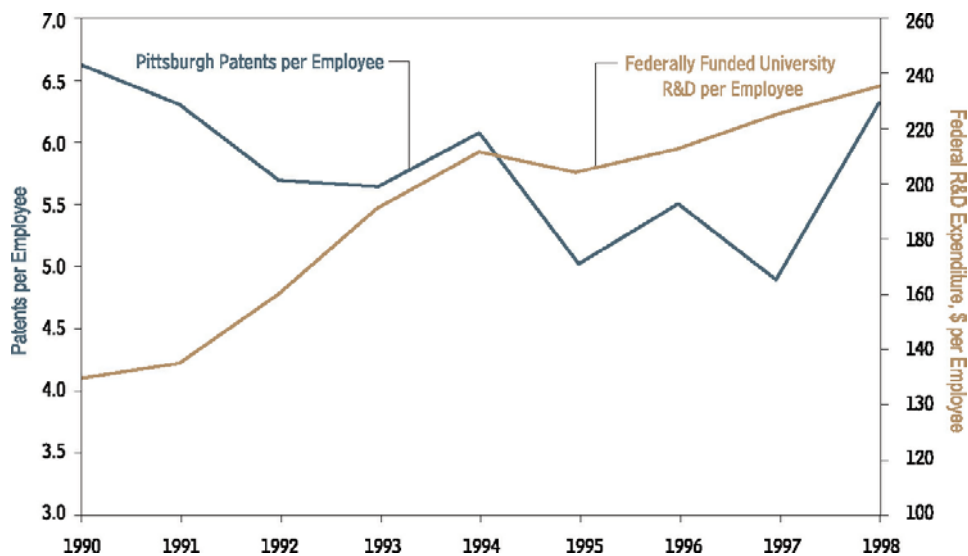
Eighty-four percent of Pittsburgh’s leaders state that research centers are available, which is 15% higher than the percent from other regions (see Exhibit 42). However, only half the amount who feels the centers are available state such centers frequently transfer knowledge into the private sector, which is 12% lower than the other regions. In addition, as the amount of federal R&D funding per capita has grown steadily over the past ten years, the number of regional patents per capita has not (see Exhibit 43). This data indicates that local R&D is under-leveraged.

Exhibit 42: Survey Results for University R&D Availability and Knowledge Transfer



Source: Clusters of Innovation Initiative, Regional Survey™

Exhibit 43: Federal R&D Investment and Patent Registration



Source: WebCASPAS Database; U.S. Patent and Trademark Office

One reason for this disparity is the decline in private sector researchers. Research and development among Pittsburgh private firms peaked in 1965 with approximately 14,500 working in research labs. The largest research firms were US Steel, Gulf Oil, and Westinghouse. US Steel cut roughly 5,000 research jobs in the 1970s; Gulf Oil, which was bought out by Chevron in the early 1980s, closed their Pittsburgh research labs, and Westinghouse cut about 3,000 research jobs throughout the 1990s, until its buy-out by CBS. By the mid 1990s, the number of private-sector researchers in the region stabilized near 8,000 (it dropped to 7,000 in 1991 but rebounded to 8,000 in 1996).⁴⁰ In addition, Standard and Poor's Compustat data indicates that regional corporate R&D dropped by 17% from 1995 to 1998. The increasing number of university researchers, now near 5,500, cannot make up the difference. As innovation becomes more important, Pittsburgh has fewer researchers.

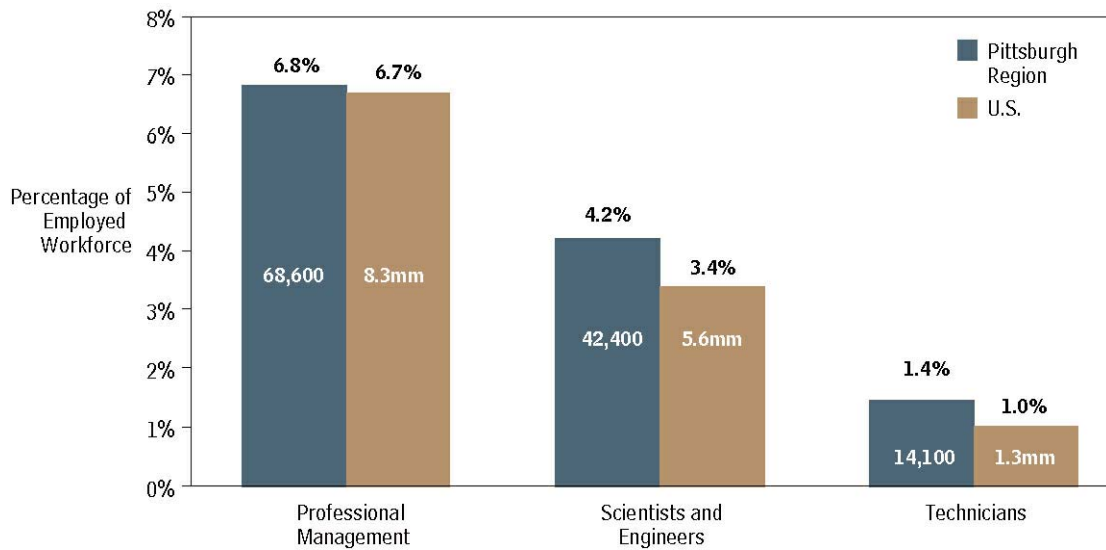
Skilled workforce. In 1998, there were 42,400 scientists and engineers, or 4.2% of the total regional workforce.⁴¹ This percentage places Pittsburgh above the national average of 3.4 % of the workforce (see Exhibit 44). The MSA also has more doctoral scientists and engineers per capita than Boston, Los Angeles, or San Francisco.⁴² In addition, the 14,100 trained technicians in the region made up close to 1.4 percent of the regional workforce, which is more than the national average of 1.0%.⁴³

In 1999, 3,500 scientists and engineers received advanced degrees from the University of Pittsburgh, and another 2,000 received the same from Carnegie Mellon.⁴⁴ University centers, such as the Pittsburgh Supercomputing Center, are designed to train students and increase the national and international pool of scientists. The Supercomputing Center, for instance, provides graduate and postdoctoral training programs in computational biology.

Among survey respondents, 37% state that available skilled labor is adequate for growth, which is similar to other regions (Exhibit 45). Nevertheless, a concern commonly expressed in interviews is that the region will have trouble growing its pool of scientists, engineers, and technicians.

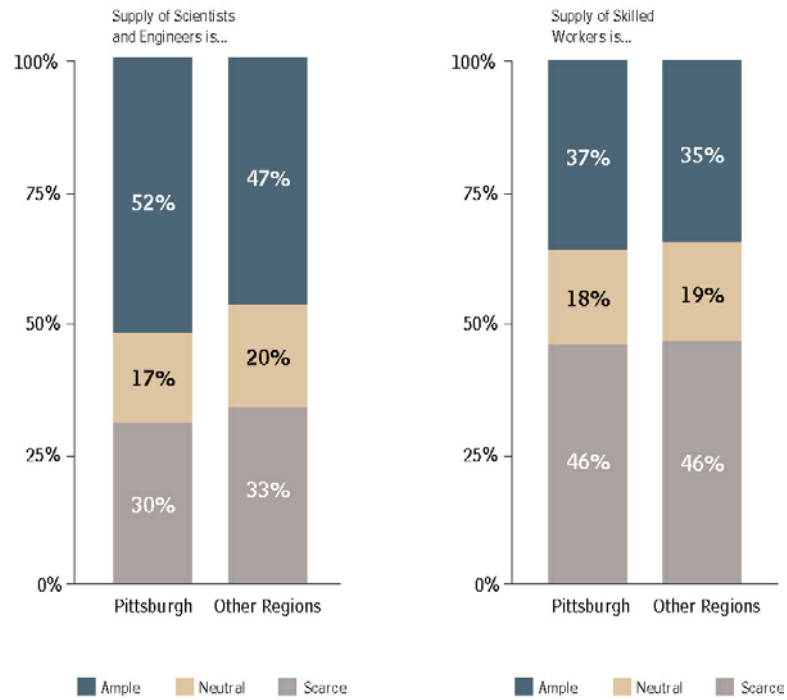
Forty-nine percent of survey respondents stated that increasing the supply of skilled workers is a future barrier to their business' growth (second most frequently cited concern), and 46% said the skilled labor pool in the region is too small.

Exhibit 44: Skilled Workforce Base in Pittsburgh and the United States, 1998⁴⁵



Source: U.S. Bureau of Labor Statistics, Occupational Employee Statistics

Exhibit 45: Supply of Scientists and Skilled Workers versus the Average of All Regions⁴⁶



Source: Clusters of Innovation Initiative, Regional Survey™

The reason for the concern is the declining percentage of younger people in the Pittsburgh population. Allegheny County has the second oldest population in the country (after Dade County in Florida). The last U.S. census shows that more than 30,000 people age 20-29 migrated from Pittsburgh during the 1985-1990 period. State data from 1997-1998 shows a net decrease of approximately 4% in that age category. During the late 1990s, when compared among the other 25 largest metropolitan areas in the United States, the Pittsburgh region has both the lowest in-migration and the lowest out-migration rate per capita (25th of 25 in both cases) of all regions studied. This may indicate that the levels of outbound migration are not as much of a problem as the inability of inbound migration to replace the younger population.⁴⁷

However, Pittsburgh recently received encouraging news, as researchers conducting a University of Pittsburgh study found 52 percent of 1999 graduates from the area's three largest schools (Carnegie Mellon, Duquesne, and the University of Pittsburgh) worked in the region, an increase from the 40 percent of 1994 graduates. While showing strong improvement, only one-third of out-of-state students remained in the Pittsburgh region after graduation in 1999. For comparison, only 20 percent of similar graduates from 1994 stayed in town for employment.⁴⁸

Quality of education. In 1999, the region's high school graduation rate of 88% was approximately 6% higher than the national average, and 4% higher than the state average.⁴⁹ The 1999 SAT level for all of Southwestern PA (1023) was slightly above the national average (1019).⁵⁰ However, in the Pittsburgh school district, the public school average SAT score (903) was more than 100 points below the national average,⁵¹ while the area spent significantly more per student (\$8,092) versus state (\$6,900) and national (\$5,700) levels.⁵² Overall, the region seems relatively optimistic, as only 36% of Pittsburgh's 202 local leaders surveyed rated the system as either poor or very poor and 43% rated it good or higher. The range of scores ranking the education system poor in other studied regions is 35% to 61%.

Physical infrastructure. Pittsburgh has a very good communications system and airport, and more than adequate power and water supply. Seventy-three percent of the respondents to the survey believed that the communications infrastructure either came close or fully satisfied their business needs.⁵³ The \$800 million airport serves 20 million passengers annually via 600 non-stop flights each day to 119 domestic and 10 international cities. However, interviewees frequently complain of poor access to the airport, a trip that is time consuming during peak hour. Local roads are becoming congested, and commute times are now longer than the national average. According to the Mobility Report, the average Pittsburgh commute time is 22 minutes to work versus 23 minutes for Boston, 21 minutes for Austin, 21 minutes for San Jose, and 29 minutes for Washington, DC.⁵⁴ In addition, Pittsburgh business and community leaders expressed moderate satisfaction (48%) with the overall quality of transportation, which compares to a range of 29% to 63% for other regions. In addition, several interview respondents are concerned that the aging water and sewage systems will need to be replaced in the near future.

Supply of risk capital. Until the last five years, Pittsburgh entrepreneurs typically had to look outside the region for seed capital. Today, both locally focused VCs, (e.g., Birchmere Ventures, and the CEO Venture Fund), and local players with a national presence (PNC Equity Management Corp, Mellon Ventures, and Adams Capital Management) have begun to funnel money into the Pittsburgh market as more than \$500 million has been invested in the region. The top 21 venture capital firms in the area have approximately \$2.5 billion in total funds, which includes a billion for PNC Equity and more than \$400 million for Mellon Bank. These firms, however, invest outside of the area as well.⁵⁵ There is currently \$1.9 billion within these VC firms that is still available, but the local investment rate is less than 30%.

Pittsburgh's annual VC funding growth has been 28% from 1995 to 2000, but this is moderate when compared to the national level of 54%.

Although interviewees state that funding access is improving in the region, most report improvements are needed—particularly in next-stage support at the IPO level. Our survey supports these interview findings. About one-third (36%) of survey respondents state that risk capital is difficult to obtain in the Pittsburgh region, while slightly less say it is easy to obtain (35%).⁵⁶ Within other regions, the range for easy access to VC funding is 53% to 29%. When asked about their overall satisfaction with how local VC firms help them to innovate, only 8% of executives state they are satisfied, whereas 32% are unsatisfied. The range for unsatisfied executives in the other four regions was 11%-27%.

Quality of life. Interviewees state that the quality of life in Pittsburgh is a positive, well-kept secret due to the low cost of living, low crime rate, and availability of cultural activities. The often-stated weakness is the lack of an urban “cool” image. Community and business leaders surveyed overwhelmingly believed that the quality of life in Pittsburgh is the most important positive factor in the regional business environment, and two – thirds felt that it made recruiting easy. In two of the other regions in the study approximately 90% felt it was an advantage.⁵⁷ Pittsburgh Mayor Tom Murphy has announced plans for a \$480 million downtown redevelopment project, but several interviewees felt this would satisfy the older population and miss on attracting new technology workers. Ideas suggested to attract technology workers are high-tech business parks with increased job availability/variety, and increased variety of restaurants, entertainment, parks, and nightlife.

Government

Government actions—by federal, state, or local agencies—affect innovation through their influence on elements of the diamond (see Exhibit 46 on next page). The Federal government's most significant positive impact in Pittsburgh has been providing funding of factor inputs. The National Institute of Health (NIH) and the National Science Foundation (NSF) funding reached almost \$300 million in R&D grants at regional universities in 2000.

A second positive action is through the state and county governments, with Governor Ridge and County Executive Roddey assisting the Pittsburgh Regional Alliance with marketing as well as tax and training incentives. State and county efforts have helped bring companies such as SONY, Rand, and Federal Express to the region. In terms of infrastructure, state and local governments have provided a state-of-the-art airport.

Approximately \$6 million in loans have been provided through the state's Innovation Works, with two-thirds of the loans for IT, and the rest for biotech projects. The state has also partnered with Carnegie Mellon University, University of Pittsburgh, and several businesses to create the Digital Greenhouse, a pilot program to assist firms with chip technology development. The state is intending to expand this program into life-science programs, which should be a boost to the biotech sector. According to interviewees, the state also provides forums on business development and provides start-ups with business support.

Both the county and the city have funds for large-scale business development loans (\$50 million and \$60 million, respectively). However, poor coordination among local governments makes it difficult to solve infrastructure issues such as upgrading roads and schools.

Local Pittsburgh leaders state that their top three government priorities are overwhelmingly to promote world-class education, promote specialized education and training programs, and improve local infra-

structure. Although there is a proliferation of training schools, which has partially addressed several of the workforce needs, and regional K-12 is above average, the quality of the K-12 education in the Pittsburgh public school district is a concern.

Exhibit 46: Government’s Impact on Pittsburgh’s Innovative Capacity

Element of the Diamond	Federal Government	State Government	Local Government
Factor Inputs	<ul style="list-style-type: none"> + Levels of R&D funding passes a quarter million annually 	<ul style="list-style-type: none"> + Technology 21 focus on 6 clusters with input from 1,000 execs for 8 point strategic plan + Tax breaks for PCs + One of 3 states to have 4 "high" tech programs among top 50 U.S. projects in civic.com awards, includes online training 	<ul style="list-style-type: none"> + Consolidated pro-business county government + County's New Idea Factory provides networking opportunities to solve local issues - Fragmented agenda at municipal level - Average school system (below average public schools)
Demand Conditions	<ul style="list-style-type: none"> + Acts as a customer for universities in order for them to receive more funding 		
Related and Supporting Industries		<ul style="list-style-type: none"> + Innovation Works provides early funding and tech expertise + Works with regions to attract outside firms + Operation Magnet to support anchor firms 	<ul style="list-style-type: none"> + Downtown revitalization with new stadiums and mall may help to attract firms - Lack of focus on attracting youth/new economy firms
Context for Firm Strategy and Rivalry		<ul style="list-style-type: none"> + Provides forums for prioritized business concerns + PA OpenforBusiness.com simplifies start-up process 	

According to Pittsburgh survey respondents, the number one barrier to expansion is the tax rate (50%) and the third highest barrier is the unfriendly to business political environment (41%). Pennsylvania has the 20th highest tax rate in the country. Only one other region we studied listed the tax burden as one of the top three issues, and no other region listed the political environment in their top three. In Pittsburgh, only 25% felt government was highly responsive to business needs, while the range for other regions is 31% to 48%.

Institutions for Collaboration

Geographic clustering of firms and related industries naturally facilitates both the interaction among firms and flow of information and resources. Nevertheless, a conscious focus on developing this interaction can bolster the process. One of the main barriers to innovation in Pittsburgh appears to be the relatively low levels of collaboration among firms and organizations within the clusters, and between universities and industry. Despite an impressive number of organizations, only 26% of surveyed executives in Pittsburgh state that institutions for collaboration are effective, versus 39% to 60% in other regions. None of the formal regional level institutions receive high approval ratings in our survey (see Exhibit 47). Of the five regions studied, survey results ranked Pittsburgh institutions for collaboration last or second to last in terms of their helpfulness.

Exhibit 47: Reported Helpfulness of Regional Institutions for Collaboration

	Percent Reporting Helpful		Percent Reporting Unhelpful	
	Established	Entrepreneurial	Established	Entrepreneurial
National Trade Associations	58%	55%	42%	45%
Economic Development Organizations	42%	44%	58%	56%
University-based Networking Organizations	39%	47%	61%	53%
Regional Industry or Cluster Councils	50%	48%	50%	52%
University Technology Transfer Offices	34%	41%	66%	59%

Source: Clusters of Innovation Initiative, Regional Survey™

University-industry linkages are especially important for fostering innovation in a region. When asked about the helpfulness of university-based connective organizations, only 47% of the respondents state they are helpful for contact and information purposes for entrepreneurial firms, versus a range of 56% to 74% for other regions. Half of survey respondents (47%) never use universities for idea development, which is low compared to other regions (ranging from 34% to 51%). Only 39% percent of respondents indicate they are satisfied with the universities' impact on the innovation process, compared to a range of 43% to 65% in other regions.⁵⁹ Although the universities are successful in obtaining funding, the results from the survey indicate that the information generated at the universities is not channeled at high rates into the business community. Given the importance of formal and informal collaborative institutions, maintaining and diversifying these assets should be a top priority.

It is important to note, however, that according to interviewees, organizations such as the Pittsburgh Technology Council and, to a lesser extent, the Enterprise Corporation of Pittsburgh and newer organizations such as the Digital Greenhouse (see Exhibit 48 on next page and Box in information technology section) appear to be making improvements in assisting with the innovation environment.

Attitudes Toward Business

Innovation is encouraged, on the one hand, by high levels of competition between rival firms, and on the other by high levels of collaboration among complementary firms. Pittsburgh business and community leaders show openness to the concepts that competition fosters innovation, that it is possible to compete and collaborate at the same time, and that firms in the cluster are better able to compete. Only one statement showed possible anti-competitive attitudes, where the majority (57%) of local leaders disagreed that the entry of a new competitor benefits the business environment.

Collaboration between firms does not appear to be strong. Only 14% of Pittsburgh respondents believe that firms in the cluster share knowledge versus 31% to 50% in other regions studied. Furthermore, only 14% believe that firms in Pittsburgh contribute to cluster programs versus 23% to 60% in other regions. As one interviewee stated, "I attend these meetings and will go to a bunch without meeting anyone. When I do meet someone it's purely by chance – there has to be a better way." Among cluster participants, only customers show strong ties for innovation. Suppliers, schools, and other cluster members do not exhibit the connectivity, and networks in general are weak.

Exhibit 46: Government’s Impact on Pittsburgh’s Innovative Capacity

Institution	Focus
Pittsburgh Technology Council Advanced Manufacturing Network Information Technology Network Biomedical Network	Serves as a networking agency for firms primarily in information technology, manufacturing and biotechnology clusters. Serves 1,600 companies, providing industry research, entrepreneur research, HR, health care coordination, and networking opportunities
Allegheny Conference on Community Development (founded 1944)	Corporate leaders work together on economic development education, workforce development and civics
Regional Alliance (includes the Chamber of Commerce)	Advocates business climate improvements; provides information and assistance to firms considering the region; markets region.
Small Business Development Centers	Contact for SBIR—(small business innovation and research) at Duquesne, St. Vincent's) work with small businesses in region
Pittsburgh Tissue Engineering Initiative	Education, networking, seed money, and tech development for biotech industry in region
The MIT Enterprise Forum	Sponsors a series of speaking and networking events aimed at entrepreneurs.
Pittsburgh Digital Greenhouse	Consortium with \$16 million state and private funding to develop SOC (System on Chip) technology with founders SONY, Cadence, OKI, Pitt, Penn State and Carnegie Mellon University
Southwestern Pennsylvania Commission	Public agency that uses collaboration to focus on transportation, economic development and government services
Pittsburgh Bioventure / Life Science Greenhouse	Consortium with target of \$600 million in public and private funding over a ten year period for life science research, technology, commercialization and economic development
Small Business Councils (formerly the Smaller Manufacturers Council)	Advocates small business issues plus HR, insurance and other services
Technology 21	Comprehensive state initiative for technology development and job training programs
SPIRC (Southwestern Pennsylvania Industrial Resource Center)	Assisting small and medium sized manufacturers improve the competitive performance. Services include manufacturing processes, quality systems, information technology and manufacturing clusters
Center for Economic Development, affiliated with Carnegie Mellon University	Providing entrepreneur and technology development since 1987 to support research and analysis

Source: Interviews and organization websites

This report looks at competitiveness with an emphasis on innovation. We have shown how regional economic performance and innovation output derives from the composition of the economy, which in turn depends upon the business environment. To assess the business environment, we used the diamond framework.

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 regional level, but our focus will be on specialized inputs (e.g., the presence of university 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 provide an in-depth analysis of the biotechnology/pharmaceutical, information technology, and production technology clusters in Pittsburgh. The first two of these clusters are good performers, while the latter experienced major contractions in the 1970s and 1980s and stabilized during the mid to late 1990s. All offer lessons for economic development.

THE BIOTECHNOLOGY/PHARMACEUTICAL CLUSTER

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

In 1999, the Pittsburgh biotechnology/pharmaceutical cluster is among the largest in the nation for number of employees, as it was ranked 22nd among 314 MSAs, employing almost 15,000.⁶⁰ Workers are prospering, with salaries that averaged \$49,797 in 1999. This was an increase from \$28,269 in 1990, improving Pittsburgh's national wage ranking from 70th to 46th.⁶¹ However, innovation levels are dropping, as the number of patents per 1,000 workers has dropped from 5.4 in 1990 to 4.7 in 1998.

At the core of the cluster are the University of Pittsburgh and the University of Pittsburgh's Medical Center's (UPMC) innovations over the last half-century, (e.g., polio vaccine and transplant technology).

These advances provide Pittsburgh with national recognition and federal funding for the university. While research has a relatively strong presence in the cluster, core subclusters such as pharmaceutical products, biological products, and consumer goods are relatively weak.

Key strengths in the innovative capacity of the regional cluster are high levels of federal funding for R&D, the high quality of research at the University of Pittsburgh Medical School, and affiliated institutions, and local demand of the aging population, which gives local firms a window on the future pharmaceutical needs of the U.S. population as a whole. However, the cluster is facing significant challenges, including weak supporting industries (e.g., specialized venture capital firms and specialized real estate), and limited opportunities for local partnerships. Perhaps most critically, industry collaboration is reported to be almost nonexistent, and institutions and associations are only beginning to gain traction. Local government is reportedly focused more on enabling old-line businesses than on biotechnology. Finally, according to surveys and interviews, the universities have some difficulty efficiently commercializing knowledge to the business community. For a summary of the economic performance, innovation output, cluster composition, and characteristics of the business environment, see Exhibit 49.

Exhibit 49: Economic Performance and Cluster Composition of the Biotech Pharma Cluster

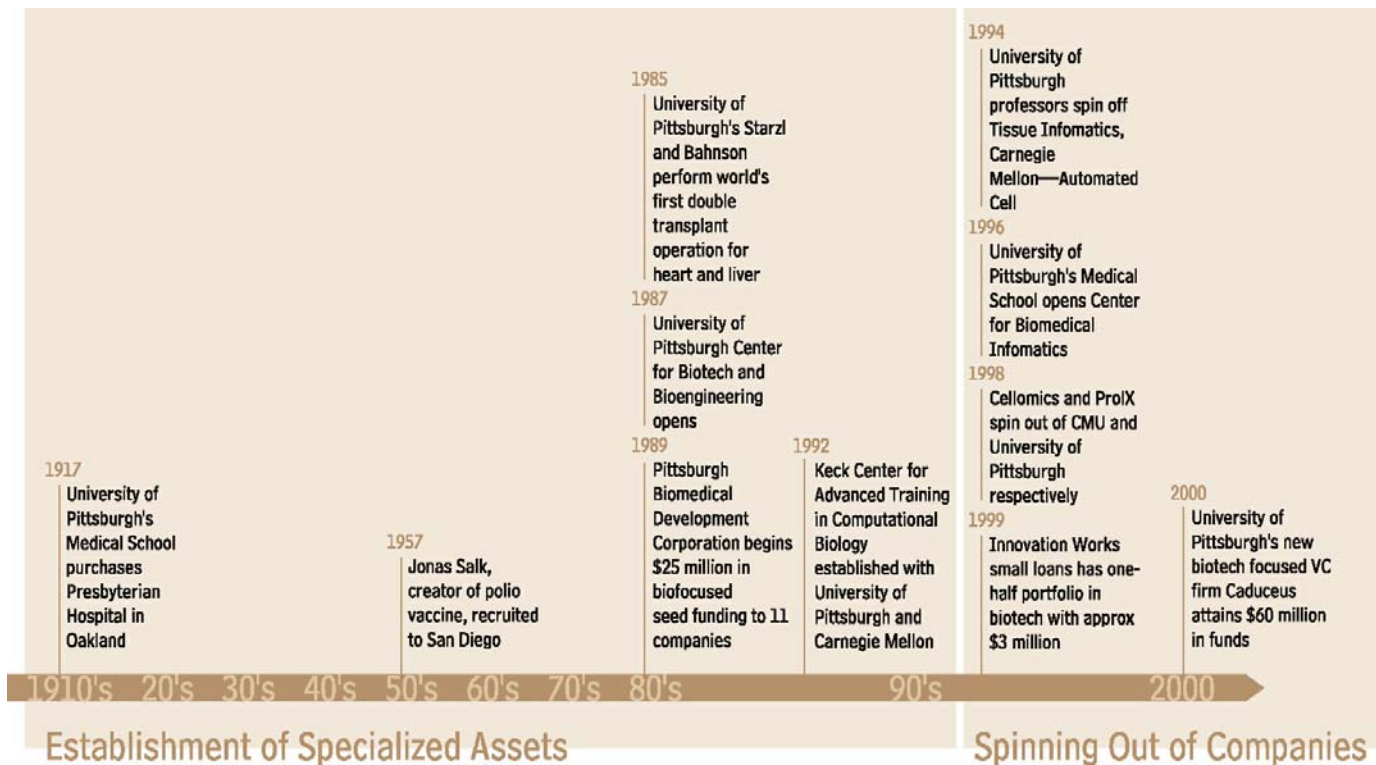
Economic Performance and Innovation Output	Cluster Composition and Business Environment
<ul style="list-style-type: none"> ■ Employment <i>1999 employment is near 15,000; 22nd largest in the U.S., up from 30th in 1990</i> ■ Wages <i>Average wage was \$49,800 in 1999; 46th highest in the U.S., up from 70th in 1990</i> ■ Patents <i>Patents per employee were 4.7 in 1998; 165th in the U.S., down from 107th in 1990</i> ■ Establishment Growth <i>Biotech/Pharma establishments grew 4.2% annually between 1990 and 1999 period; Pittsburgh fell in rank from 27th to 32nd in total establishments</i> ■ Venture Capital Investments <i>Venture funding totaled \$5.5 million between 1995 and 2000; but a related \$45 million in medical devices</i> 	<ul style="list-style-type: none"> ■ Young cluster, but growing industries ■ Strong position in related medical devices ■ New funding from Innovation Works and Caduceus, a Bio-VC firm ■ Strong clinical practice and aging population provide early insights to national needs ■ High levels of R&D—over \$220 million at University of Pittsburgh ■ Numerous specialized research and training centers ■ Small cluster, within core industries; but almost among top 20 for broad cluster ■ Survey results show weak R&D commercialization processes ■ Weak ties with other cluster members ■ Local competition with very limited cluster contribution

Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School; Pricewaterhouse Money Tree database

DEVELOPMENT OF PITTSBURGH'S BIOTECHNOLOGY/PHARMACEUTICAL CLUSTER

In the 1950s, Jonas Salk and a research team from the University of Pittsburgh developed the first vaccine to fight polio. Many people consider this a key event that put the University of Pittsburgh and its Medical Center on the research map. Another high-profile event occurred in 1984, when Drs. Thomas E. Starzl and Henry T. Bahnson performed the world's first double transplant operation, replacing the heart and liver of six-year-old Stormie Jones. Such events, and more generally, the magnitude and commitment of the University of Pittsburgh's focus on bioscience research, created the foundations for the commercial development of the cluster.

Exhibit 50: Pittsburgh Biotechnology/Pharmaceuticals Timeline



Source: Interviews

It was not until the 1990s, however, that a significant number of biotech firms were started. The University of Pittsburgh and its Medical Center have generated many start-ups, such as Automated Cell, and Precision Therapeutics. Pharmaceuticals are a small part of the cluster, but new pharmaceutical firms (such as ProIX co-founded in 1995 by a University of Pittsburgh alumnus) are entering the market. Pittsburgh is also beginning to attract bioscience firms, such as CellSource, Gene Foundry, Solo Hill and IFI Biologics which all opened operations to partner with UPMC research institutions.⁶²

It was also in the 1990s that Carnegie Mellon University began developing leading-edge basic and applied biomedical research programs, especially in applied clinical research. Carnegie Mellon is becoming involved with collaboration between information technology research groups and molecular and cellular biologists, chemists, and engineers, in conjunction with clinical practice and biomedical research at the University of Pittsburgh and UPMC.

Cellomics, created in 1998, is an example of a company in this field. Combining research advances in biology, chemistry, and information technology, the company's mission is to improve the efficiency of the drug discovery process by eliminating the need for animal trials. Cellomics was scheduled to have its IPO in early 2001 on the NASDAQ, but is not listed as of summer 2001. The issues of Cellomics speak to the issues of biotech startups, as it incurred \$11 million in expenses, primarily in R&D, but needs to delay its IPO due to market conditions, despite generating almost \$3.5 million in revenues in its first year in 1999.

CASurgica was founded in 1997 by Anthony M. DiGioia, III, M. D., and Branislav Jaramaz, Ph. D., to commercialize the results of collaborating between the Centers for Medical Robotics and Computer Assisted Surgery (MRCAS).⁶³ The research was funded in part through a peer-review National Challenge Grant from the National Science Foundation. CASurgica, Inc. develops computer-assisted tools and technologies to enable more accurate and less invasive surgery. It partners with the Center for MRCAS, formed in 1993 as a joint venture between Carnegie Mellon University and Shadyside Hospital,⁶⁴ and the Center for Orthopedic Research at UPMC Shadyside Hospital. See Exhibit 51 for the key events and issues in the development of Pittsburgh's biotech cluster.

Exhibit 51: Building the Pittsburgh Pharmaceuticals and Biotechnology Cluster

Historical Obstacles	Important Enablers	Key Events
<ul style="list-style-type: none"> ■ Lack of local venture capital or specialized support services ■ Heavy science and engineering focus, with lack of specialized management/marketing expertise ■ "Lack of large community inhibits sharing ideas"—no major pharma center/difficult for start-ups to gather data ■ Problems attracting best talent to region, keeping young people ■ Non-existent VC/Angel Funding 	<ul style="list-style-type: none"> ■ UPMC opens Center for Biomedical Informatics; and Center for Biotechnology and Bioengineering ■ VC is just beginning in biotech—now approaching \$20 million—Ben Franklin/Innovation Works is providing small-scale start-up funds—US biotech firms raise \$36 million in 2000 ■ Recent introduction of University of Pittsburgh technology transfer office and affiliated Caduceus VC fund/New funding scheduled on Digital Greenhouse Model 	<ul style="list-style-type: none"> ■ University of Pittsburgh's development of organ transplant technology in 1950s puts Pittsburgh on the map ■ Salk and a team of Pitt researchers develop the first vaccine to fight polio in 1955 ■ University of Pittsburgh surpasses \$200 million in life science funding in 2000 ■ Firms such as Cellomics and Prolix, Automated Acell, Interscope Technologies begin to spin out of the U of Pittsburgh

Source: Interviews, Clusters of Innovation Regional Survey™

Case Study of UPMC and the University of Pittsburgh

The UPMC was founded in 1893, now includes 17 hospitals, and has more than 3,000 physicians and more than 25,000 employees. UPMC's spending accounts for nearly \$750 million a year in non-salary expenditures to the local economy, which translate into an additional 50,000 jobs in the region.

Research has fueled much of UPMC Health System's growth. University and affiliated researchers have published more than 15,000 papers over the past 10 years, ranking it among the top hospital-associated research institutions in the country. Overall, the university received roughly \$300 million in funding in 2000, of which more than 80% is for medical/biotech research. UPMC/Pitt is the conduit for 86% of NIH funding flowing into the region and currently ranks in the top ten of all biomedical institutions in the United States for this funding. Examples of university research include the first preliminary success in using gene therapy to treat diseases such as arthritis, cancer, and inherited genetic defects, and the Starzl Transplantation Institute, which is the busiest transplant center in the world, conducting research in anti-organ-rejection drugs.

The University of Pittsburgh established the new Center for Biotechnology and Bioengineering in 1987, which focuses on development, evaluation, and implementation of new concepts for therapies, and bioinstrumentation. Collaboration is also beginning to develop between universities in the region. During the 1990s, the Keck Center for Advanced Training in Computational Biology was established as a joint venture with Carnegie Mellon University.⁶⁵ Currently, there are almost 30 biotech related centers within the University of Pittsburgh, Carnegie Mellon University, and Duquesne University with some affiliation to UPMC.

Collaboration is also beginning between the schools and the business community. UPMC is supporting research efforts that develop a working relationship between clinicians and bioengineers. UPMC funds research initiatives such as the Pittsburgh Tissue Engineering Institute and the McGowan Center for Artificial Organ Development. UPMC seed money has also helped launch a venture capital fund in 1999, Caduceus Capital Health Ventures, which focuses its \$60 million portfolio on biotech firms, and provides advice and funding to firms such as Stentor, PhytoMedica, and Enanta Pharmaceuticals. Finally, the Office of Technology Management at the University has recently been created to encourage innovation by bringing university scientists and the business community together. Although it has received mixed reviews, it is beginning to gain momentum as supervises the preparation of roughly 40 new patent applications from a annual portfolio of 110 invention disclosures, and develops commercialization strategies for these patent-pending technologies and for a number of additional non-patented technologies.

The schools are also promoting cross-cluster collaboration. For example, University of Pittsburgh's Center for Biotechnology and Bioengineering promotes a multidisciplinary approach to molecular and cellular biology for the development of new products and ongoing research in areas such as artificial heart and lung development, human gene therapy, tissue engineering, and biomolecular materials. Additionally, the university and its medical center collaborate with Carnegie Mellon's Robotics Institute and Research Institute.

Examples of University of Pittsburgh's Biotech Firms⁶⁸

The University of Pittsburgh has been spinning out a myriad of biotech firms dating back to the 1970s, but generating firms at a higher level in the mid to late 1990s. For example, Charles Brinton, Ph.D., and Sarah Wood, DSc., both from the University of Pittsburgh's Department of Biological Sciences, founded

Bactex in 1974. Bactex has developed a number of products, including new vaccines for animal and human use, in partnership with large pharmaceutical firms.

Automated Cell formed to commercialize the CytoWorks™ system, a new platform for investigation of cellular processes. Automated Cell patents were generated from the University of Pittsburgh Medical School and Carnegie Mellon University. The Company is currently working on InnovationWorks/Ben Franklin funding and is seeking outside financing / partners.

Precision Therapeutics, Inc., founded in 1995, tests patients' tumor cells against available chemotherapeutic agents to provide physicians with information, based on tissue culture tests, to aid in their choice of therapy for patients. It has raised money from Ben Franklin, Pittsburgh Biomedical Development Corporation, and private investors.

InterScope Technologies, Inc. (formerly DFD Information Services, Inc.) was founded in 1997, by pathologists and engineers from the University of Pittsburgh Medical Center's Division of Pathology Informatics. It specializes in thin client technology, digital imaging and the Internet. The Company has received multi-firm venture backing from Mid-Atlantic Venture Funds and Birchmere Investments, Inc., hired senior development engineers from Lycos, and started development of products for pathology with its flagship product, Abintra™, an automated digital imaging system for the field of pathology.

RECENT CLUSTER PERFORMANCE

Employment. In 1999, Pittsburgh had 14,978 biotechnology and pharmaceutical workers in the MSA (see Exhibit 52).⁶⁹ It has 1.1% of total national employment in the cluster,⁷⁰ which is above average for a metro area the size of Pittsburgh. Over the 1990 to 1999 period, Pittsburgh's biotechnology and pharmaceutical cluster enjoyed strong employment growth of 4.4% per year. This growth lifted its ranking from the 30th largest cluster in 1990 to 22nd in 1999. Growth has been led by increased employment in medical devices, laboratory instruments, and research.

We also benchmark the Pittsburgh region using the economic area as the geography of reference, and using the narrow cluster definition (see Exhibit 53). The economic area is relatively accessible in a single working day, and so contains assets that are part of the cluster. The narrow cluster definition only includes subclusters that are the core of the cluster. Measured this way, the cluster employs 1,980 people, and is the 29th largest, up from 33rd in 1990.

Exhibit 52: Employment and Average Wages in the Fifteen Largest Biotech/Pharmaceutical Clusters, MSA, Broad Cluster Definition

Metropolitan Statistical Area	Total Employment 1999	CAGR 1990-1999	Share of National Employment 1999	Average Wages 1999	CAGR of Average Wages 1990-1999
Boston-Worcester-Lawrence-Lowell-Brockton, MA-NH	74,721	1.7	5.6	\$63,496	6.2
Chicago, IL	65,329	-0.7	4.9	\$52,196	6.0
Los Angeles-Long Beach, CA	47,143	-1.6	3.5	\$46,359	4.3
Newark, NJ	43,693	2.2	3.2	\$73,415	7.0
New York, NY	43,245	2.1	3.2	\$56,192	6.4
Washington, DC-MD-VA-WV	39,973	5.4	3.0	\$60,118	6.9
Philadelphia, PA-NJ	37,374	-1.9	2.8	\$56,547	4.2
San Diego, CA	34,244	5.4	2.5	\$61,712	6.1
Minneapolis-St. Paul, MN-WI	33,654	5.3	2.5	\$41,523	2.4
San Jose, CA	33,006	5.3	2.5	\$88,940	8.4
Middlesex-Somerset-Hunterdon, NJ	30,520	0.5	2.3	\$61,468	7.2
Nassau-Suffolk, NY	27,432	-1.0	2.0	\$38,970	2.7
Orange County, CA	26,237	1.4	2.0	\$48,099	2.9
New Haven-Bridgeport-Stamford-Danbury-Waterbury, CT	21,779	0.4	1.6	\$63,865	6.7
Oakland, CA	19,651	0.8	1.5	\$57,719	4.7
Pittsburgh, PA (22nd)	14,978	4.4	1.1	\$49,797	6.5

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

Wages. In 1999, average pay in the Pittsburgh MSA broad biotech/pharma cluster was \$49,797 (see Exhibit 52). Over the 1990 to 1999 period, Pittsburgh’s biotech/pharma wage increased at an average annual rate of 6.5% versus 3.4% for St. Louis and 6.2% for Boston. Pittsburgh’s overall ranking for average wage increased from 70th to 46th nationally. Wages were lower for the economic area, which is typical because more rural areas with a lower cost of living are included in the EA.

Exhibit 53: Employment and Average Wages in the Fifteen Largest Biotechnology/Pharmaceutical Clusters, Economic Area, Narrow Cluster Definition

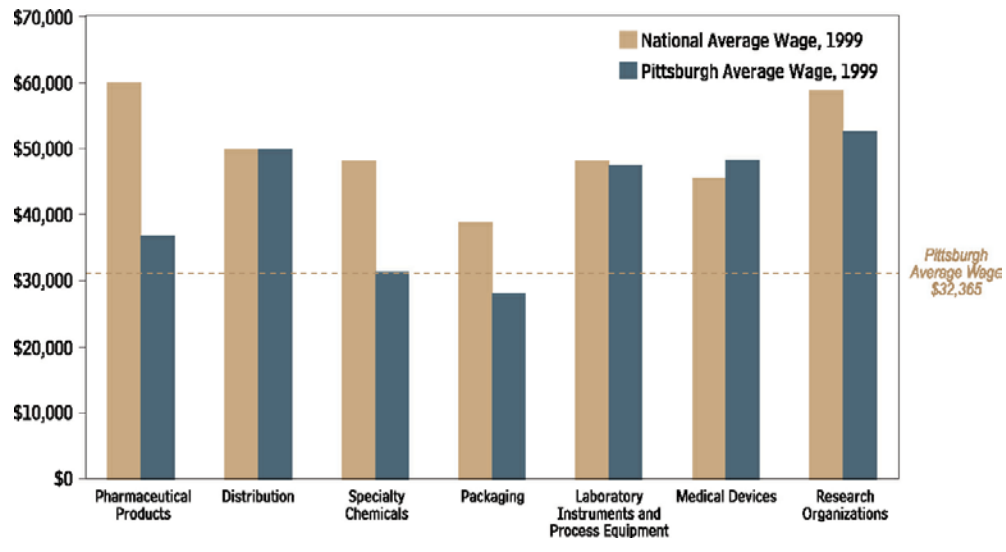
Economic Area	Total Employment 1999	CAGR 1990-1999	Share of National Employment 1999	Average Wages 1999	CAGR of Average Wages 1990-1999
New York-No. New Jersey-Long Island, NY-NJ-CT-PA-MA-VT	75,918	-0.1	29.4	\$59,887	7.4
Los Angeles-Riverside-Orange County, CA-AZ	20,142	2.4	7.8	\$37,272	2.8
Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD	11,491	-5.7	4.5	\$38,718	-2.3
Grand Rapids-Muskegon-Holland, MI	9,524	4.3	3.7	\$0	0.0
Indianapolis, IN-IL	9,496	-0.9	3.7	\$0	0.0
Raleigh-Durham-Chapel Hill, NC	8,501	4.0	3.3	\$49,331	0.0
Chicago-Gary-Kenosha, IL-IN-WI	7,961	-12.4	3.1	\$37,533	2.9
Boston-Worcester-Lawrence-Lowell-Brockton, MA-NH-RI-VT	7,837	10.2	3.0	\$53,348	4.1
Dallas-Fort Worth, TX-AR-OK	7,673	7.9	3.0	\$34,595	3.2
San Francisco-Oakland-San Jose, CA	7,604	4.2	2.9	\$47,737	1.8
St. Louis, MO-IL	5,640	7.1	2.2	\$43,384	7.8
Washington-Baltimore, DC-MD-VA-WV-PA	5,052	4.1	2.0	\$0	0.0
Syracuse, NY-PA	3,808	4.9	1.5	\$0	0.0
Cleveland-Akron, OH-PA	3,731	5.9	1.4	\$35,396	0.0
Atlanta, GA-AL-NC	3,590	3.6	1.4	\$31,187	2.5
Pittsburgh, PA-WV (29th)	1,980 (29th)	1.9 (78th)	0.8 (29th)	\$37,273	0.0

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

Among sub-clusters, only medical devices paid higher than the national average, while pharmaceutical products, specialty chemicals, packaging, and research organizations fell well below the national averages (see Exhibit 54). Pittsburgh's distribution subcluster was equal to the national average, and laboratory instrument(s) was also very similar.

Patents. In 1998, firms in the metro area biotech/pharmaceuticals cluster (broad definition) registered 68 patents, an increase from 46 in 1988 (see Exhibit 55). This gives it a 0.8 percent share of the patent development in the nation, a decrease in Pittsburgh's national ranking for patents from 21st to 31st in the ten years ending 1998. The patents per employee decreased during that time from 4.9 to 4.7, dropping Pittsburgh's national ranking from 107th to 165th .

Exhibit 54: Pittsburgh Biotech/Pharma Cluster Sub-Cluster Average Wages, 1999



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

Exhibit 55: Establishments and Patents in the Fifteen Largest Biotechnology/Pharmaceutical Clusters, Metro Area, Broad Cluster Definition

Metropolitan Statistical Area	Total Establishments 1999	CAGR of Total Establishments 1990-1999	Total Patents 1988	CAGR of Patents 1990-1998	Patents per 1,000 Employees 1998
Boston-Worcester-Lawrence-Lowell-Brockton, MA-NH	1,426	5.2	639	13.8	9.0
Chicago, IL	1,025	2.0	259	5.3	4.0
Los Angeles-Long Beach, CA	1,382	2.5	232	9.6	5.0
Newark, NJ	416	1.8	156	2.3	3.8
New York, NY	1,074	1.5	274	9.0	6.6
Washington, DC-MD-VA-WV	1,065	4.8	261	14.0	7.0
Philadelphia, PA-NJ	769	3.0	379	10.1	10.2
San Diego, CA	823	8.7	365	22.8	11.5
Minneapolis-St. Paul, MN-WI	553	5.4	199	9.9	6.1
San Jose, CA	662	7.1	363	15.5	11.7
Middlesex-Somerset-Hunterdon, NJ	345	5.4	160	4.0	5.4
Nassau-Suffolk, NY	553	2.1	86	8.3	3.3
Orange County, CA	717	4.8	144	9.1	5.9
New Haven-Bridgeport-Stamford-Danbury-Waterbury, CT	361	2.9	153	8.2	6.4
Oakland, CA	533	6.4	219	12.2	11.7
Pittsburgh, PA (22nd)	279	4.2	68	2.9	4.9

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

Leading regions in patent generation in 1998 include Boston (635), Philadelphia (379), San Diego (365), and San Jose (363). However, smaller employment regions, such as Seattle, Baltimore, and Madison have had substantial patent growth and surpassed Pittsburgh in patent registration.

Looking at the EA, and using the narrow cluster definition, the number of patents per employee almost quadruples from the broad MSA to the narrow economic area in 1998 (see Exhibit 56). Growth in patents per worker, however, is modest compared to other top regions.

Exhibit 56: Establishments and Patents in the Fifteen Largest Biotechnology/Pharmaceutical Clusters, Economic Area, Narrow Cluster Definition

Economic Area	Total Establishments 1999	CAGR of Establishments 1990-1999	Total Patents 1988	CAGR of Patents 1990-1998	Patents per 1,000 Employees 1998
New York-No. New Jersey-Long Island, NY-NJ-CT-PA-MA-VT	467	0.5	542	7.0	7.4
Los Angeles-Riverside-Orange County, CA-AZ	278	3.1	148	16.0	7.4
Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD	78	3.0	238	11.0	18.6
Grand Rapids-Muskegon-Holland, MI	16	1.1	19	7.0	2.8
Indianapolis, IN-IL	31	4.0	89	12.0	9.5
Raleigh-Durham-Chapel Hill, NC	24	7.0	61	19.0	7.3
Chicago-Gary-Kenosha, IL-IN-WI	101	1.8	110	7.0	11.6
Boston-Worcester-Lawrence-Lowell-Brockton, MA-NH-RI-VT	80	4.2	311	19.0	43.4
Dallas-Fort Worth, TX-AR-OK	64	1.4	32	9.0	4.3
San Francisco-Oakland-San Jose, CA	88	5.2	403	18.0	50.5
St. Louis, MO-IL	44	3.2	60	14.0	11.1
Washington-Baltimore, DC-MD-VA-WV-PA	45	6.7	189	22.0	37.0
Syracuse, NY-PA	21	1.8	14	8.0	5.6
Cleveland-Akron, OH-PA	26	2.3	25	6.0	6.1
Atlanta, GA-AL-NC	48	3.5	42	15.0	13.7
Pittsburgh, PA-WV (29th)	17 (29th)	6.3 (52nd)	24(26th)	12.0 (70th)	16.1 (68th)

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

Establishments. We use establishment growth as a proxy for new firm formation. The number of establishments in the MSA grew from 179 in 1990 to 272 in 1999, a 4.2% annual growth rate. This was a moderate pace, slower than eight of the top 15 regional clusters (all of which are growing a significantly larger base number of establishments). The EA/narrow cluster definition does better (primarily due to the shift to a narrow definition focus), with a growth rate of 6.3% being faster than 13 of the top 15 clusters.

VC funding and IPOs. According to PriceWaterhouseCoopers Money Tree database, Pittsburgh's biotechnology and pharmaceutical firms receive little investment capital. Over the 1995 to 1999 period, only one biotech venture capital deal was completed, and it was valued at under \$1 million. In the first

three quarter of 2000, however, biotechnology and pharmaceutical firms received almost \$5 million, for a total of \$5.5 million during the period. This was 0.2% of the national total, much less than Pittsburgh's 1.1% of national cluster employment.

The funding in the biotech and related industries is only beginning, as almost 90% of VC funding from the past six years occurred in the first three quarters of 2000. A related field, medical devices, received another \$45 million in funding, while another related field, health care, received almost \$49 million in venture capital funding. Almost two-thirds of the biotech/pharma cluster is also listed as medical devices.

A promising sign is the new Caduceus Venture Capital fund, in affiliation with the University of Pittsburgh and its affiliated Medical Center, which has \$60 million in funds for investment in regional biotech. Although no investment has been made by the fund in Pittsburgh as of late 2001. Alternatively, Innovation Works, the state-funded organization, has more than one-third of its \$6 million dollars in biotech start-ups. The Future Fund, a venture capital fund with almost \$200 million in assets under management, has also provided capital to a couple of biotech start-ups – Precision Therapeutics and Automated Cell. LaunchCyte is another firm which has obtained first round funding; its focus is on providing incubator services and funding to biotech firms. However, Pittsburgh's biotech cluster is struggling to push IPOs into the market. Not since the early 1990s - when AMSCO International (1991) and Medrad Inc. (1992) went public - have any Pittsburgh biotech firms gone public. Cellomics, which appeared to be ready for an IPO in late 2000, is delaying to market conditions and no firms have launched as of yet.

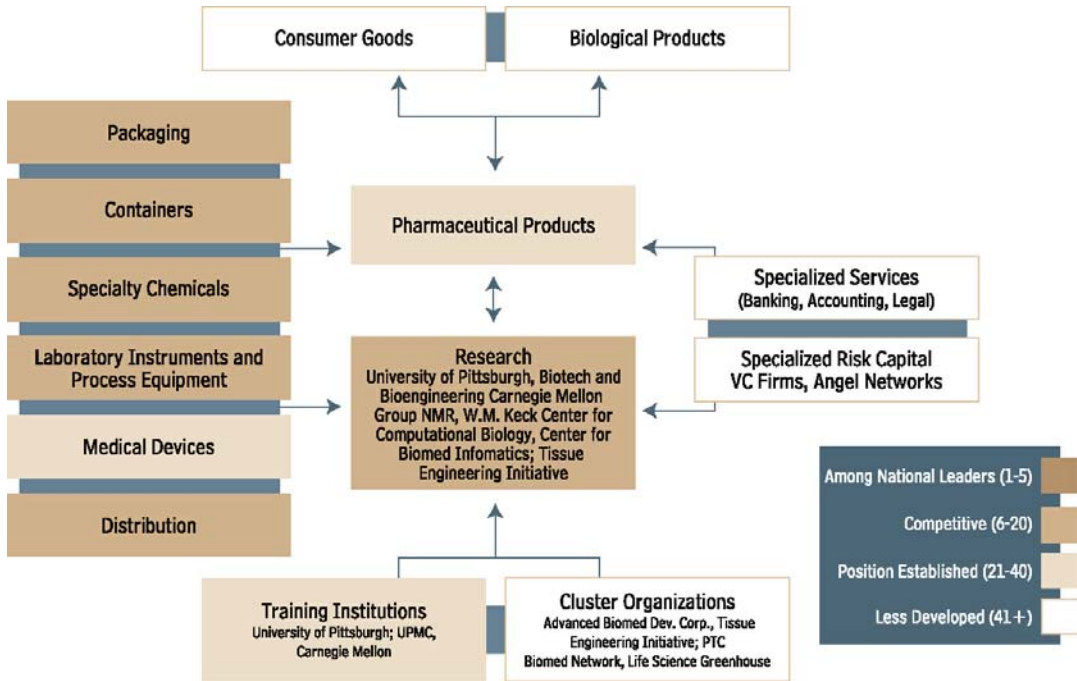
DESCRIPTION OF THE REGIONAL BIOTECHNOLOGY/PHARMACEUTICAL CLUSTER

Exhibit 57 depicts the competitive position of the Pittsburgh 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 subclusters present in the region; their relative strength has been statistically assessed by the Cluster Mapping Project.

Laboratory instruments and research organizations are the key drivers of economic activity, with high employment and solid growth. Laboratory instruments employ approximately 4,000 and research organizations employ almost 3,800.⁷¹ Distribution is another strong subcluster, with a relatively high share of national cluster employment and strong growth. The containers subcluster is above the national averages for size and growth, but is fairly small.

Other subclusters in the region are less impressive. Specialty chemicals and packaging are fairly large—each over 1,000 employees, and have a relatively high share of national employment, but are shrinking. Medical devices are fairly large, with a percent above the national share, yet they are falling behind the national growth rate. Pharmaceutical products, biological products, and consumer goods, are core subclusters, have low shares of national cluster employment, and are shrinking against the national averages. The cluster is also relatively weaker for specialized services, and specialized capital providers. According to our survey, the majority of senior biotechnology executives felt that the cluster is still emerging (77%). The biotech/pharma associations and networks, which promote collaboration and ensure productive government relations, are only at the development stages.

Exhibit 57: Competitive Position of the Pittsburgh Biotechnology/Pharmaceutical Cluster; Economic Area, Narrow Cluster Definition



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

Exhibit 58 shows the competitive position of the cluster at an industry level.

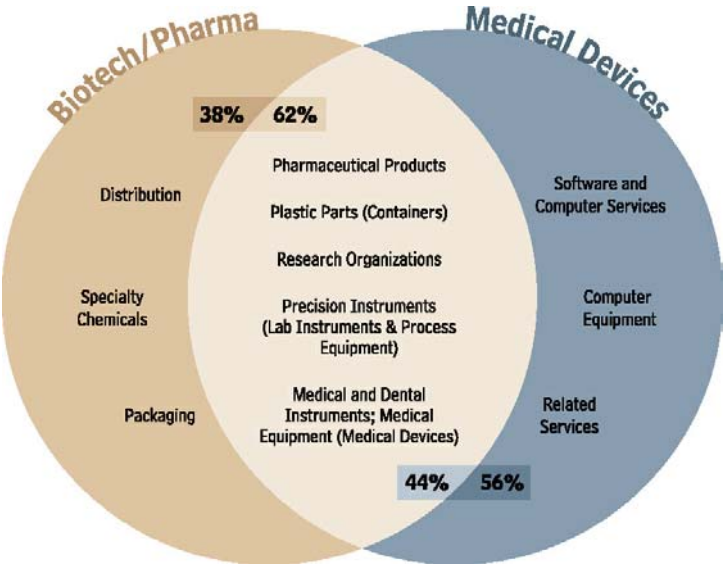
Exhibit 58: Pittsburgh's Pharma / Biotech Sub-Clusters and Industries 1999

Subcluster	SIC	Industry	National Industry Share	Total Employment 1999	Employment CAGR 1990–1999
Total Cluster			1.1	14,978	4.4
Pharmaceutical Products	2833	Medicinals and botanicals	0.0	173	-16.4
	2834	Pharmaceutical preparations	0.1	0	-100.0
Containers			1.4	550	13.6
	3085	Plastics bottles	1.4	550	13.6
Consumer Goods			0.1	75	0.7
	2844	Toilet preparations	0.1	75	0.7
Distribution			0.9	1,842	5.6
	5120	Drugs, proprietaries and sundries, wholesale	0.9	1,842	5.6
Biological Products			0.3	60	0.0
	2836	Biological products except diagnostic	0.3	60	0.0
Specialty Chemicals	2843	Surface active agents	1.9	1,209	-0.9
	2865	Cyclic crudes and intermediates	0.0	0	-100.0
	2899	Chemical preparations, n.e.c.	2.9	515	-0.7
Packaging			1.8	694	-1.1
			3.1	1,284	-1.7
	3221	Glass containers	3.8	750	-4.4
	3466	Crowns and closure	9.1	375	0.0
	3497	Metal foil and leaf	0.9	159	
			2.5	3,928	6.5
Laboratory Instruments and Process Equipment	3821	Laboratory apparatus and furniture	0.4	80	-4.4
	3823	Instruments for process measurement	2.8	1,294	25.9
	3826	Analytical instruments	3.9	1,358	5.5
	3827	Optical Instruments and lenses	3.0	559	2.8
	3829	Measuring and controlling devices, n.e.c.	1.8	637	-0.1
Medical Devices			0.6	1,599	4.8
	2835	Diagnostic substances	0.2	69	
	3841	Surgical and medical instruments	0.3	344	31.1
	3843	Dental equipment and supplies	0.1	20	0.1
	3844	X-ray apparatus and tubes	0.5	70	0.0
	3845	Electromedical equipment	2.0	1,026	21.7
	3850	Ophthalmic goods	0.3	70	0.0
Research Organizations			1.2	4,258	10.1
	6794	Patent owners and lessors	0.8	212	3.5
	8731	Commercial physical research	1.3	3,044	8.9
	8733	Noncommercial research organizations	1.2	1,002	18.8

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

It should be noted that the biotech/pharma cluster is very similar to the medical device cluster, as employment in each of the broad clusters overlaps, particularly in pharmaceutical products, plastic parts, research organizations, precision instruments, and medical and dental instruments. As Exhibit 59 indicates, 62% of biotech/pharma employment is also in the medical device cluster.

Exhibit 59: Pittsburgh Biotechnology/Pharmaceutical and Medical Device Cluster Redundancy



Note: Parentheses is biotech/pharma sub-cluster name; Pharmaceuticals included with employment at 919; percents include all cluster employment
 Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School; [SubClusters with EA Employment over 1,000](#)

CLUSTER INNOVATIVE CAPACITY

Pittsburgh’s biotechnology and pharmaceutical cluster is in the early stages of development. There are about 90 firms in the region, which are paying relatively high wages. However, there is virtually no IPO activity, with only moderate VC activity, and low rates of patent registration. On noteworthy strength of the cluster is its capability in clinical trials management. Commercial firms, such as NOVUM Pharmaceutical Research Services and Pittsburgh Clinical Research Network, and federally sponsored organizations, such as the National Surgical Adjuvant Breast and Bowel Project, who provide tamoxifen’s efficacy as a breast cancer preventative, have established Pittsburgh as a leader in clinical trials. These organizations and their personnel offer the cluster a pool of expertise that is valuable to entrepreneurial firms developing biologics, drugs and medical devices.

Despite lagging innovation output, 60% of the biotech executives surveyed considered the region to be a good location for innovation. The explanation lies in the high quality of the business environment, and specifically in the cluster's capacity for innovation (see Exhibit 59). The strengths of the business environment include high levels of federal investment in R&D, high quality universities and research centers, and a large pool of specialized scientists and engineers. On the other hand, cluster leaders are concerned that future growth in the region could be limited by a number of factors, including government responsiveness to needs, availability of skilled labor, and the cost of doing business. Perhaps more important, the connective links among firms and organizations in the cluster do not appear to be as effective as they could be. Interviewees state that the cluster is just gaining momentum, and that local relationships in the cluster are not well developed. Interviewees and survey respondents recognize the high potential for innovation due to the quality and quantity of research in the area, but the relatively low levels of collaboration limit current innovation output.

Specialized research. Pittsburgh's biotechnology and pharmaceutical cluster is home to more than 170 life-science research institutions throughout the UPMC system and the University of Pittsburgh. Carnegie Mellon is also beginning to introduce technology into the sector, partnering with the University of Pittsburgh, and hiring experts in biotech studies to expand related R&D in the university.

The research centers at the University of Pittsburgh have attracted more than \$220 million in total funding for bioscience research. A record \$173 million was received from the NIH, restoring the University of Pittsburgh's national ranking to tenth. Funding from the National Science Foundation also reached a new high, totaling \$16 million. The number was lower, according to WebCASPAP, where federal funding was reported to grow almost 9.0% annually, from \$72 million in 1988 to \$169 million in 1998. The WebCASPAP data are similar to NIH numbers.⁷²

According to our survey, 84% of biotech executives stated that specialized facilities for research are readily available to their firm, but only 36% reported that these institutions frequently transfer knowledge. Several interviewees expressed frustration with the inability of the tech transfer offices or the research institutions themselves to get results out into the private sector. Exhibit 60 on the following page lists key university research institutes in the metro area.

Specialized training and talent base. The University of Pittsburgh is the primary source for providing the life sciences industry in Pittsburgh with talent. Its medical school is ranked in the top 20 research schools in the country.⁷³ Of the biotech managers interviewed, they cite universities less for the benefits of their research centers and more for talented people they attract and develop. However, several interviewees were concerned about the available talent in the region. The survey also indicated that this could be a problem, as only 40% of the executives surveyed felt that the region provides an ample supply of scientists and that the pool of skilled workers was sufficient for their growth needs.⁷⁴

The University of Pittsburgh has responded to the shortage of life science students by introducing a graduate program focused on bioengineering in 1989 and an undergraduate program in 1996. In addition, students complete internships with local biotechnology and biomedical companies. In 1998 the University of Pittsburgh created a department of bioengineering within its School of Engineering and has established relationships with more than 20 local firms and hospitals - including UPMC - that will help place students.⁷⁵ Carnegie Mellon also provides a basis for life science and related information technology and robotics scientists and engineers.

Exhibit 60: Major Biomedical Research Institutes in Pittsburgh

Institution	Focus
University of Pittsburgh Medical Center <ul style="list-style-type: none"> Center Biomedical Informatics (1966) Center for Clinical Pharmacology (1991) McGowen-Artificial Organ Development Office of Research, Health Sciences (1995) 	<ul style="list-style-type: none"> Collaboration point for informatics at University of Pittsburgh; UPMC Research drug evaluation, education Transplants; product innovation, commercialization Biomed research in six health science schools
University of Pittsburgh <ul style="list-style-type: none"> Center for Biotech & Bioengineering (1987) Center for Neuroscience (1991) Combinatorial Chemistry Center (1998) Office of Technology Management 	<ul style="list-style-type: none"> New technology from research in biotech fields Research and graduate training Accelerate chemistry discovery Technology transfer office
Carnegie Mellon University <ul style="list-style-type: none"> Biomedical Supercomputing Initiative Carnegie Mellon University Research Institute/Biotech Group Light Microscope Imaging & Biotechnology Center Medical Robotics and Information Technology in Medicine and Surgery (MERITS) Microelectromechanical Systems Laboratory 	<ul style="list-style-type: none"> Advance computer resources for biomedical industry Practical applications of new capabilities (closing 2002) NSF funded research Foster robotic technology within medicine Research on batch fabrication processes
Joint Carnegie Mellon University and University of Pittsburgh <ul style="list-style-type: none"> W.M Keck/Advanced Training Computational Biology Center for Cognitive Brain Imaging Center-Neutral Basis of Cognition (1994) NMR Center for Biomedical Research (1986) Institute for Complex Engineered Systems University of Pittsburgh Cancer Institute 	<ul style="list-style-type: none"> Training for computational biology Research for functional magnetic resonance Research on neutral basis of cognitive processes Biomedical research technology facility Includes tissue engineering and artificial organ initiatives Research, care, education and community outreach
Duquesne <ul style="list-style-type: none"> Mylan School of Pharmacy 	<ul style="list-style-type: none"> Five research groups with technological focus
Pittsburgh Tissue Engineering Initiative	<ul style="list-style-type: none"> Education, networking, seed money and tech development for biotech industry in region

Source: Interviews, organization websites

Context for firm strategy and rivalry. A good context is characterized by high levels of both competition and collaboration among firms in a cluster. The Pittsburgh pharmaceutical / biotechnology cluster does not do well in either category. Thirty-one percent of respondents agree that firms “frequently” share knowledge, versus a 31% to 50% range for all respondents in other regions. Few (only 14%) agree that firms frequently contribute to cluster-wide programs, versus a range of 23% to 54% for other regions. Biotech executives report little competition compared to other surveyed regions. Only 37% percent of survey respondents described competition as “intense,” and even less (32%) said there were a large number of local competitors – the lowest share of responses among studied regions.

Sophistication of regional demand. Pittsburgh biotechnology and pharmaceutical executives expressed slightly positive views about the level and sophistication of interaction with their local customer base. One possibility mentioned is the high number of elderly residents, who would be a primary target base for pharmaceutical and biotech firms. Although more than 60% of the respondents believed that their regional customers were sophisticated and demanding, they did not indicate that this demand provided them with a competitive advantage. About half (46%) of the executives stated that customer feedback led to product improvements, versus 43% to 59% for other regions.⁷⁶ It is worth noting here that better linking institutions could help improve customer feedback and enable firms to learn more from their sophisticated local demand in order to generate innovations.

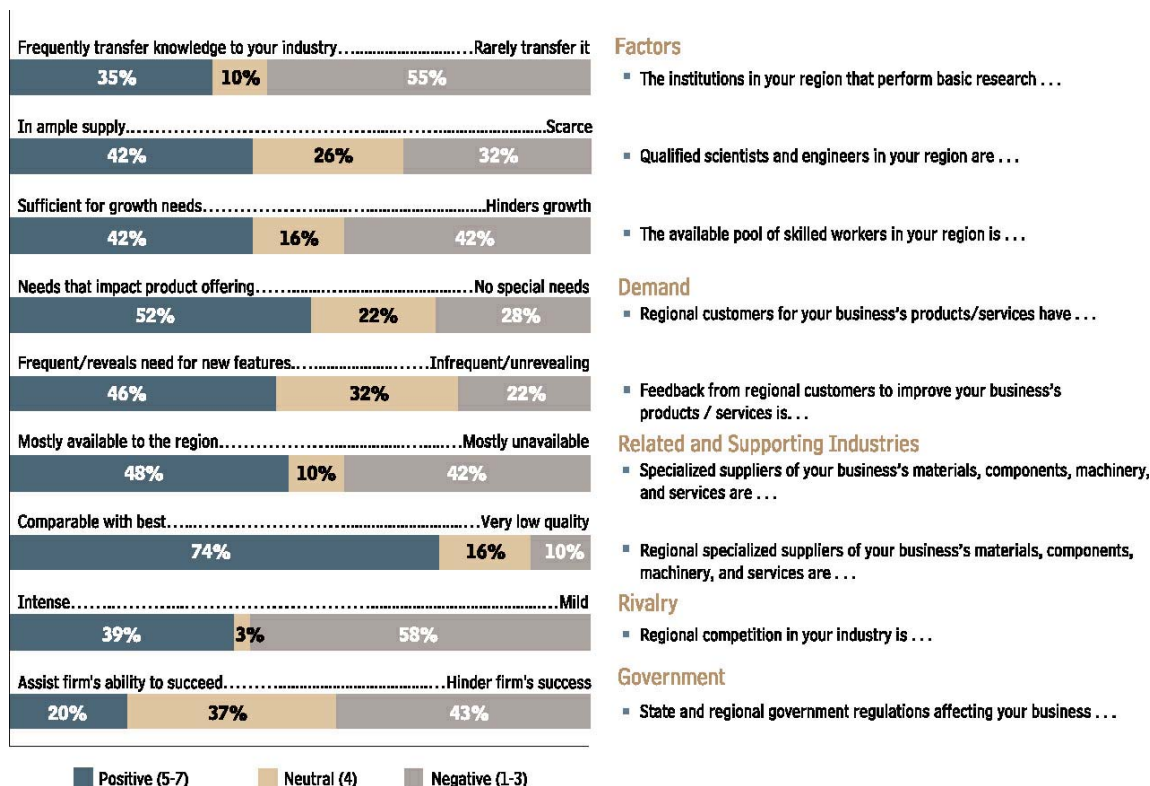
Related and supporting industries. Pittsburgh lacks a strong network of firms and associations to provide specialized support for legal, human resource, venture capital, and real estate service that contains sterile laboratory space for biotech firms. Most interviewees state that there needs to be improvement in these areas. More than three out of four in the biotech survey sample agreed that the cluster is still emerging, with a narrow range of businesses and organizations involved.

According to executives in the biotech/pharma cluster, related and supporting industries are high quality, but not abundant (see Exhibit 61). Most survey respondents (74%) state that these firms provide high-quality goods and services. However, only 48% reported that specialized suppliers were frequently available in the region, and 42% said they frequently had to go outside the region to source materials, components, and services. Only 27% stated that specialized suppliers frequently help them in the innovation process,⁷⁷ and only 27% stated that related firms frequently help in the innovation process. In other regions, responses were as high as 48%. Each of these ratings were less than the average across all regions surveyed.

Government. The federal government provides significant funding to support university research. The state funds Innovation Works, a program with a good reputation among biotech firms as being helpful to the cluster by offering funding and business support. Half of its portfolio is biotech firms.

However, interviews and surveys show that the impact of local government is less positive. Only 20% of biotech respondents felt that state and local regulations are appropriate for their firms to succeed; the range for the other regions was 18% to 51%. Twenty percent report that state and local funding for R&D is ample; in other regions, between 26% and 46% stated it was ample. Finally, only 16% of surveyed biotech executives felt that government can work with the needs of the business, versus 20% to 25% for all respondents in other regions.

Exhibit 61: Select Survey Results from Pittsburgh Biotech/Pharmaceutical Executives



Source: Clusters of Innovation Initiative Regional Survey™

Executives from the survey have outlined a fairly basic agenda for government. Top priorities include: providing world-class primary and secondary education (83%), providing education and training programs (83%), simplifying compliance procedures (70%), simplifying the regulatory environment (63%), and improving the transportation infrastructure (60%).

Institutions for collaboration. There are several institutions in Pittsburgh that are designed to develop networking within the biotech cluster. Organizations such as the Biomedical Network within the Pittsburgh Technology Council are beginning to create linkages among cluster members, and to work on key issues within the cluster. The Biomedical Network hosts informational and network events monthly, participates in regional economic development efforts, undertakes projects in workforce development and technology commercialization issues, informs the cluster of recent developments through Council publications, and serves as an informal conduit for information between industry participants. The Network assists firms and organizations for collective action. For example, it organizes biotech firms to attend meetings at potential lab sites, and in some cases as many as 25 firms have attended these meetings. In addition, the network helps members find funding sources both within and outside the area.

A recent positive development is the creation of the Pittsburgh Life Sciences Greenhouse, which is becoming the central economic development entity driving the growth of the local biomedical industry. Seeded through state tobacco settlement funds, the Life Sciences Greenhouse is embarking on an ambi-

tious and comprehensive 10-year, \$600 million program spanning more than a dozen specific activities addressing the infrastructure, university faculty recruitment, business development assistance, entrepreneurship, seed-funding, company attraction, human capital, technology commercialization, and regional marketing needs of the emerging biomedical cluster. The Greenhouse will work with existing institutions and firms to coordinate the community-wide collaborative actions that will drive the formation, growth, and attraction of biomedical firms in the region.

According to executives we surveyed at entrepreneurial firms, university based linking institutions, economic development organizations, and national trade associations were helpful, whereas technology transfer offices and regional cluster organizations were weaker. Executives at established firms reported receiving less help. Given the importance of basic research to a biotech cluster, improving the ratings of university-based organizations and technology transfer offices is a high priority (see Exhibit 62).

Exhibit 62: Select Survey Results on Pittsburgh’s Biotech Institutions for Collaboration

	Percent Reporting Helpful		Percent Reporting Unhelpful	
	Established	Entrepreneurial	Established	Entrepreneurial
National Trade Associations	68%	65%	32%	35%
Economic Development Organizations	48%	63%	52%	37%
University-based Networking Organizations	27%	56%	73%	44%
Regional Industry or Cluster Councils	31%	46%	69%	54%
University Technology Transfer Offices	27%	35%	73%	65%

Source: Clusters of Innovation Initiative Regional Survey™

There appears to be a dichotomy of opinion concerning support from universities. Interviewees from firms that have spun out of the university report that the university is very supportive. In contrast, interviewees without close university affiliation report that they were not at all helpful.

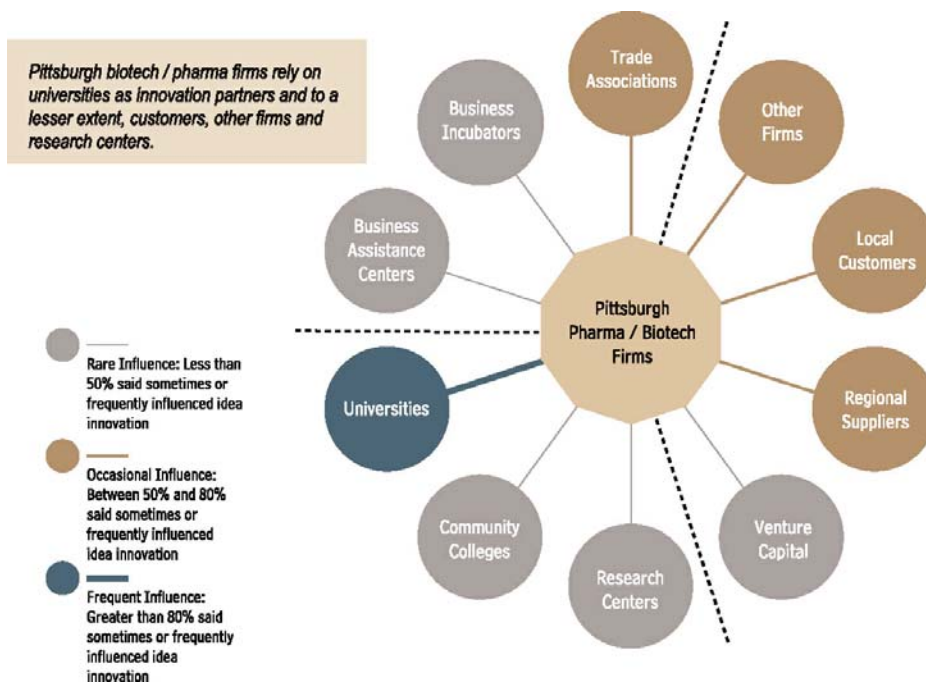
Similar to the quality of linking institutions, the patterns of collaboration within the cluster also vary considerably. To learn more about collaboration throughout the innovation process, cluster firms were asked to identify their partners in three phases of new product or service innovation: idea generation, idea development, and commercialization. In Pittsburgh, our results show that biotechnology and pharmaceutical firms tend to rely much more on universities in the idea development and generation stage than in the commercialization stage (see Exhibit 63). Essentially they do not rely significantly on any other organization. Although the data is only directional, it appears that for other regions, firms rely on universities, research institutes, and on other firms.

CONCLUSION

Two critical assets for developing a biotech/pharma cluster are high-quality local research and human talent. Pittsburgh’s cluster has both. Nevertheless, the cluster produces very few patents, a key measure of innovation. Several factors may help to explain this gap between potential and actual performance. First, no biotech cluster relationships other than universities had strong benefits on firm innovation, according to the survey results. Within these relations, the University of Pittsburgh’s tech transfer office

is relatively new and only generated \$5 million in fees in 1999. The survey indicates that this may need to improve, as 84% of the respondents ranked research centers as available but only one-third state they regularly transferred technology. Second, funding is a concern as little of the \$550 million in local VC funding is going to biotech,⁷⁹ and few other alternatives such as Innovation Works exist. Third, business leaders list availability of skilled labor as a key problem (according to 44%). Finally, firms have been growing strongly only in the last half of the 1990s. Due to the relative youth of the industry, it will take time for supplier firms to develop regionally. While the cluster is growing, its core in pharmaceuticals and biological products is very weak nationally. But as the following case study shows, these obstacles can be overcome by implementing a sound firm-wide strategy.

Exhibit 63: Frequency of Interaction among Cluster Members on Idea Generation



Source: Clusters of Innovation Initiative Regional Survey™

Case Study – Overcoming Obstacles in Pittsburgh:⁸⁰

Pittsburgh-based ProIX Pharmaceuticals started in 1996, and the six-person company has successfully located office/lab space, secured financing, and hired executive-level management/staff while preparing its first anti-cancer drug (PX-12) for preclinical evaluations. ProIX decided to locate in Pittsburgh for a number of reasons, according to ProIX CEO Dr. Lynn Kirkpatrick, including the region's universities and their reputation for having vast experience with clinical trials. She notes a certain buzz in the air that Pittsburgh's biomedical industry is evolving into a national/international hub. The company has a milestone plan to initiate a trial every two years; start a human resources department; expand its research/lab space; and get a drug to the marketplace in three to five years. Even as the local industry has to draw more executive management, build infrastructure, and attract capital to cement its leading status, ProIX management is finding ways to overcome these obstacles.

Obstacle #1 – Executive Management. The Pittsburgh region is rich with researchers and scientists developing ideas for the technology pipeline. However, most researchers do not have the business expertise needed to run a company and get its product to the marketplace. ProIX brought in Angela Maher to serve as its COO and CFO. With more than 15 years of finance experience, Maher previously worked at the executive finance level with Forbes Health Systems. Lynn Kirkpatrick came to ProIX from Saskatchewan, Canada, where she was a professor of chemistry at the University of Regina since 1983. By combining Maher and Kirkpatrick's finance and research expertise respectively, ProIX "kills one big bird with two stones." The rest of ProIX's business and research staff is secured with Dr. Andreas Vogt as scientific director, Dr. John Lazo, and Dr. Garth Powis, all from the University of Pittsburgh.

Obstacle #2 – Capital. Maher says ProIX has been able to fund its research with a combination of personal investments and small business loans. Finding venture capital for biomedical startups can be difficult due to the length of time needed to get products to market. "We've looked at VCs, but moved more in the direction of small business loans," says Maher. ProIX was recently awarded a \$2.1 million National Cancer Institute (NCI) Phase II Small Business Innovation Research (SBIR) Grant to be spent over the next four years for continued development of PX-12, a drug inhibiting the growth of diseased cells in a variety of cancers. This was one of the largest SBIR grants ever made.

Obstacle #3 – Incubator Space. Vogt befriended Christian Manders of Promethean LifeSciences at a seminar and discovered office and lab space were available right next door to Promethean's offices in the Forbes Med Tech Center. ProIX moved into the new space and currently shares lab space with Promethean. With inexpensive lab space in short supply locally, Vogt says this unexpected solution has worked out exceptionally well and will allow ProIX to expand as necessary.

THE INFORMATION TECHNOLOGY CLUSTER IN PITTSBURGH

The information technology (IT) cluster at the national level is composed of industries that design, manufacture, and sell both computer hardware and software devices and services. The cluster includes research instruments, IT services and software, and communication equipment. It contains providers of specialized inputs, such as chip technology and software and hardware. The cluster also encompasses areas of communication technology, including industries such as communication equipment and telephone and telegraph equipment. 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 areas with the highest share of national cluster employment are San Jose, Southern California, Boston, and the Tri-State/New York metropolitan area.

Pittsburgh's information technology cluster has grown modestly over the decade, moving from the 36th largest IT cluster in the nation in 1990 to 32nd in 1999. Wages, however, have risen more slowly than the national average for IT. Moreover, patents per worker lags well behind other regions, with the Pittsburgh IT cluster falling from 51st highest IT cluster in 1990 to 123rd in 1999.⁸¹

Our assessment of cluster innovative capacity finds that specialized factor inputs (e.g., R&D funding, local universities, and entrepreneurial professors) were critical to cluster development. However, several factors in the business environment help explain the clusters modest economic performance and poor innovation output. These include: limited venture capital, inefficient commercialization mechanisms, little networking across cluster members, institutions that are not able, despite their efforts, to generate collaboration, and low levels of competition (see Exhibit 64).

Exhibit 64: Economic Performance and Cluster Composition of the Information Technology Cluster

Economic Performance and Innovation Output	Cluster Composition and Business Environment
<ul style="list-style-type: none"> ■ Employment <i>1999 employment over 20,000 is 32nd largest in nation—improving from 36th in 1990</i> ■ Wages <i>Average wage of \$55,350 in 1999; 5.5% annual growth between 1990 and 1999 slower than the U.S. rate</i> ■ Patents <i>Patents per employee are at 3.6 in 1998; dropping it from 51st to 123rd between 1988 and 1998</i> ■ Establishment Growth <i>IT establishments grew 7.2% annually between 1990 and 1999; maintaining its rank in total establishments at 25th</i> ■ Venture Capital Investments <i>Software firms raised almost \$180 million between 1995 and 2000</i> 	<ul style="list-style-type: none"> ■ A relatively young and small cluster ■ Particularly small in core industries Presence in software Weak in computers and peripherals ■ Numerous scientists and engineers ■ High levels of R&D funding ■ Numerous specialized research and training centers ■ Weak R&D commercialization processes ■ Low levels of local competition ■ Low levels of inter-firm collaboration ■ Weak linkages among cluster members

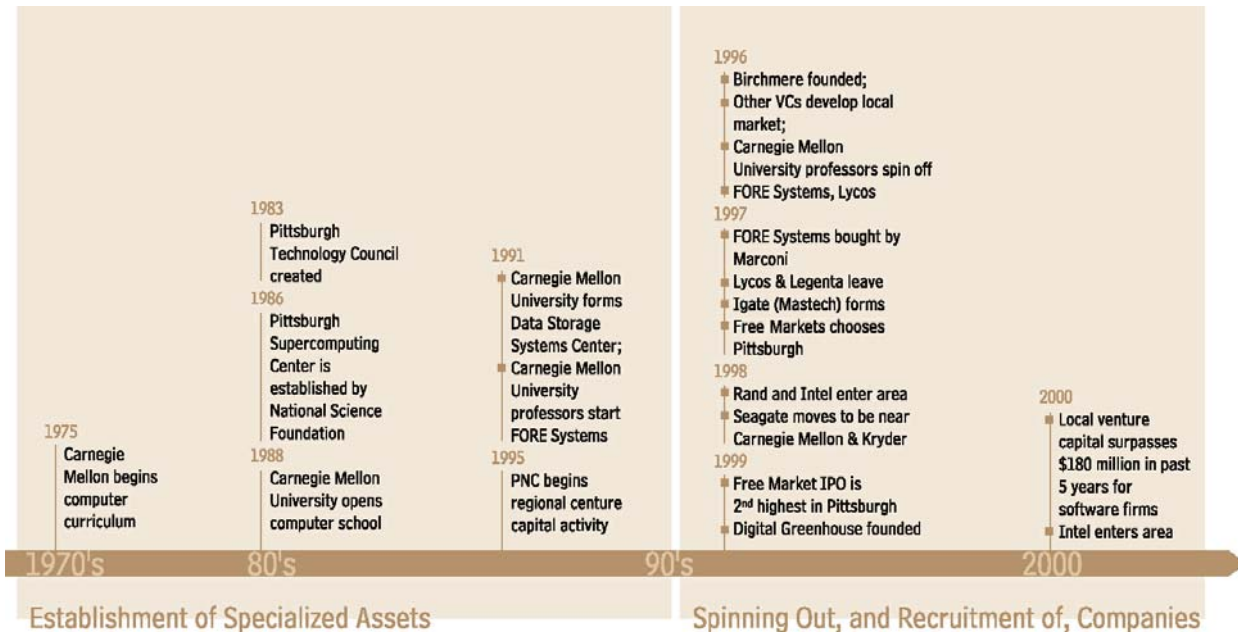
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School; Pricewaterhouse Money tree database

DEVELOPMENT OF PITTSBURGH'S INFORMATION TECHNOLOGY CLUSTER

Local universities and government investment seeded Pittsburgh's information technology cluster, with universities spinning out firms, beginning in the late 1970s (See Exhibit 64). The beginnings of the IT cluster in Pittsburgh can be traced back to Carnegie Mellon University's purchasing its first computer in 1958, and its focus in the 1960s and 1970s on developing a computer science curriculum. Early successful spinouts from Carnegie Mellon University included the Carnegie Group in the early 1980s. Next, Carnegie Mellon University opened its supercomputing center in 1986, funded by the NIH, and soon thereafter developed the computer curriculum into its own school in 1988. Enhancing this is the quality of Carnegie Mellon's engineering school, ranked among the top ten in virtually every ranking (see Exhibit 65).

Like the pharmaceutical / biotech cluster, the IT cluster began producing a significant number of firms only in the 1990s. CMU professors started a number of companies, including LYCOS, iGATE Technologies, FreeMarkets, and FORE Systems. All four had IPOs. FORE Systems not only inspired other professors to enter the start-up cycle, such as the founders of FreeMarkets, but also spun out several other firms such as Co-Manage, Laurel Networks, Accelight Networks, and Yourfit. Prior to FORE Systems, IT activity in the region was limited. FreeMarkets, formed in 1995, now has offices in 14 countries and six cities in the United States. As an e-marketplace, buyers find qualified suppliers, quality goods and services, and competitive pricing on an international scale, and suppliers improve inventory management. After the company went public at an opening price of \$48 in December 1999, within a month its market price approached \$350 per share, giving it the highest market cap of any firm in the history of the region. This both set a mood of optimism for many information technology firms in the region and assisted FreeMarkets to expand internationally. However, the market price is currently at a fraction of its opening price.

Exhibit 65: Pittsburgh Information Technology Timeline



Source: Interviews

Due to reasonable costs and the universities' reputation, several other technology-based firms entered the area, including SONY, Intel, Rand, and Seagate in the late 1990s. In addition, the Commonwealth of Pennsylvania provided funding for the Pittsburgh Digital Greenhouse, an economic development initiative started in June 1999 to build an industry cluster around the application of System On Chip (SOC) technology in the digital multimedia and digital networking markets (see box insert). With the support of Pennsylvania's universities, private foundations, regional development organizations, state and local government, and private industry, the Greenhouse is focusing on economic expansion and job creation in the 21st century. The Greenhouse is creating jobs by attracting new companies to the region, helping local members grow, and fostering start-ups.⁸²

In addition, information security is growing in Pittsburgh and is becoming one of the national leaders. The Software Engineering Institute's Computer Emergency Response Team continues to receive government funding for their advances in securing information and the Internet. In addition, Red Siren has emerged as a leader on a national level. With the events of September 2001, revenue and employment in the sub cluster should continue to grow in the coming years.⁸³

One of the most critical organizations for information technology in the region, the Pittsburgh Technology Council, began in 1983 to help facilitate the growth and connectivity of the industry. It now has 1,600 members, which are all either technology companies or supporting firms, and organizes networking and information/educational events for member firms.

Exhibit 66: Building the Pittsburgh Information Technology Cluster

Historical Obstacles	Important Enablers	Key Events
<ul style="list-style-type: none"> ■ Strong "mill" culture has hindered the credibility of the new technology businesses ■ Initial hesitancy by universities for private partnerships—tech transfer offices still not considered effective ■ Lack of local venture capital ■ Lack of local networking ■ Lack of strong regional suppliers ■ Problems attracting best talent to region, keeping young people—"image is of blue collar town with bad weather—bounded housing and not a lot of suburban development." 	<ul style="list-style-type: none"> ■ World-class academic research centers ■ Government R&D funding ■ Universities spin out firms, several gaining national prominence, such as FORE Systems, Lycos, Free Markets—several also act as anchor firms ■ Eleven universities within a radius of 50 miles ■ Venture capital funding surpasses \$500 million over five years ending in 2000; \$180 million in software 	<ul style="list-style-type: none"> ■ Formation CMU's Research Institute and Software Research Institute ■ Birchmere begins in 1996 and focuses a VC industry on new technology industries in Pittsburgh ■ Free Markets has second largest market capitalization in history of Pittsburgh ■ Pittsburgh universities collaborate on Digital Greenhouse, a chip technology initiative that sets model for firm collaboration within the cluster, with government and other organizations

Source: Interviews

The Pittsburgh Digital Greenhouse (PDG) was founded in 1999, and is an economic development initiative sponsored by the Commonwealth of Pennsylvania. It has a focused mission: to build an industry cluster around the application of System On Chip (SOC) technology in the digital multimedia and digital networking markets. It has the support of Pennsylvania's universities, private foundations, regional development organizations, state and local government, and private-industry firms. The PDG sells memberships and receives grants for funding. Its private sector participants include Benchmark Photinics, Bridge Semiconductor, Cadence, Casio, CDT (Cable Design Technologies), Cisco Systems, Compunetix, inc., IMD (Intelligent Micro Designs), and Laural Networks. Each is a leader in designing, developing, or utilizing SOC technology in digital multimedia or digital networking applications. These companies direct PDG research, provide input to its education and training programs, and collaborate with other PDG members and partners.

The Digital Greenhouse uses funds provided by partners and members to develop programs in SOC education and training, SOC research, talent recruitment, electronics infusion, and expansion support. The focus is to create regional jobs by attracting established companies, helping local members grow, and fostering start-ups. The Digital Greenhouse has over \$4 million in seed money to support the start-up community. It does so by addressing the factors that determine where technology companies locate, grow, and prosper, including access to technology, talent, markets and partners, and a business-friendly environment:

ACCESS TO TECHNOLOGY The Greenhouse funds advanced SOC research that is directed by and licensed to the PDG members. The Greenhouse also provides informal access to the large base of SOC research teams located in the region.

ACCESS TO TALENT The Greenhouse programs provide an excellent opportunity for companies to work directly with the faculty and students at their three member universities. It also has a formal talent recruitment program for member facilities located in the region. The SOC education program is developing a unique curriculum to enable members to upgrade the engineering skills of their current workforce.

ACCESS TO MARKETS & PARTNERS Greenhouse memberships provide both formal and informal opportunities to network with senior representatives from companies that are leading the development of the digital multimedia and digital networking markets.

Its success has created a template for development of a life-science greenhouse project in Pittsburgh, to be developed with the use of federal tobacco funds.

RECENT ECONOMIC PERFORMANCE

Employment. In 1999, there were 20,008 employees in the Pittsburgh MSA IT cluster (broad definition), which was the 32nd largest IT cluster in the country. Employment in the cluster has grown 5.2% annually over the 1990 to 1999 period, which was faster than the national rate of 3.6% and grew at the tenth fastest rate among the top 20 markets. During this time it moved from the 36th largest market in 1990 (see Exhibit 67 on next page).

Exhibit 67: Employment and Average Wages in the Twenty Largest Information Technology Clusters, Metropolitan Statistical Area, Broad Cluster Definition

Metropolitan Statistical Area	Total Employment 1999	% CAGR 1990-1999	% Share of National Employment 1999	Average Wages 1999	% CAGR of Average Wages 1990-1999
San Jose, CA	207,154	2.6	7.4	\$94,965	9.0
Boston-Worcester-Lawrence-Lowell-Brockton, MA-NH	174,805	2.2	6.2	\$70,187	7.1
Washington, DC-MD-VA-WV	129,943	6.1	4.6	\$68,752	6.3
Chicago, IL	115,421	2.6	4.1	\$66,910	7.5
Los Angeles-Long Beach, CA	94,164	0.3	3.3	\$49,706	4.0
Dallas, TX	90,189	6.6	3.2	\$67,347	6.0
Orange County, CA	76,287	2.6	2.7	\$55,887	5.5
San Diego, CA	64,689	7.1	2.3	\$82,339	10.7
Atlanta, GA	60,522	8.9	2.2	\$67,052	5.4
New York, NY	57,227	2.9	2.0	\$69,806	7.2
Philadelphia, PA-NJ	54,639	3.2	1.9	\$61,836	6.3
Minneapolis-St. Paul, MN-WI	54,370	2.7	1.9	\$53,778	4.8
Austin-San Marcos, TX	54,143	7.3	1.9	\$65,433	7.1
Oakland, CA	53,163	5.4	1.9	\$71,758	7.6
Phoenix-Mesa, AZ	49,946	2.9	1.8	\$53,562	5.0
San Francisco, CA	48,937	7.3	1.7	\$99,086	10.4
Seattle-Bellevue-Everett, WA	48,181	9.4	1.7	\$92,114	11.7
Raleigh-Durham-Chapel Hill, NC	44,080	1.4	1.6	\$59,071	6.4
Portland-Vancouver, OR-WA	41,505	8.7	1.5	\$59,933	5.6
Nassau-Suffolk, NY	38,378	0.7	1.4	\$59,225	6.0
Pittsburgh, PA (32nd)	20,008	5.2	0.7	\$55,345	5.5

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

We also benchmark the Pittsburgh region using the economic area as the geography of reference, and using the narrow cluster definition (see Exhibit 68). The economic area is relatively accessible in a single working day, and so contains assets that are part of the cluster. The narrow cluster definition only includes subclusters that are the core of the cluster. Measured this way, the cluster employs nearly 4,550, and is the 35th largest. The lower ranking for the EA, narrow cluster definition, is due to much lower employment in the core subclusters in the Pittsburgh IT cluster.

Exhibit 68: Employment and Average Wages in the Fifteen Largest Information Technology Clusters, Economic Area, Narrow Cluster Definition

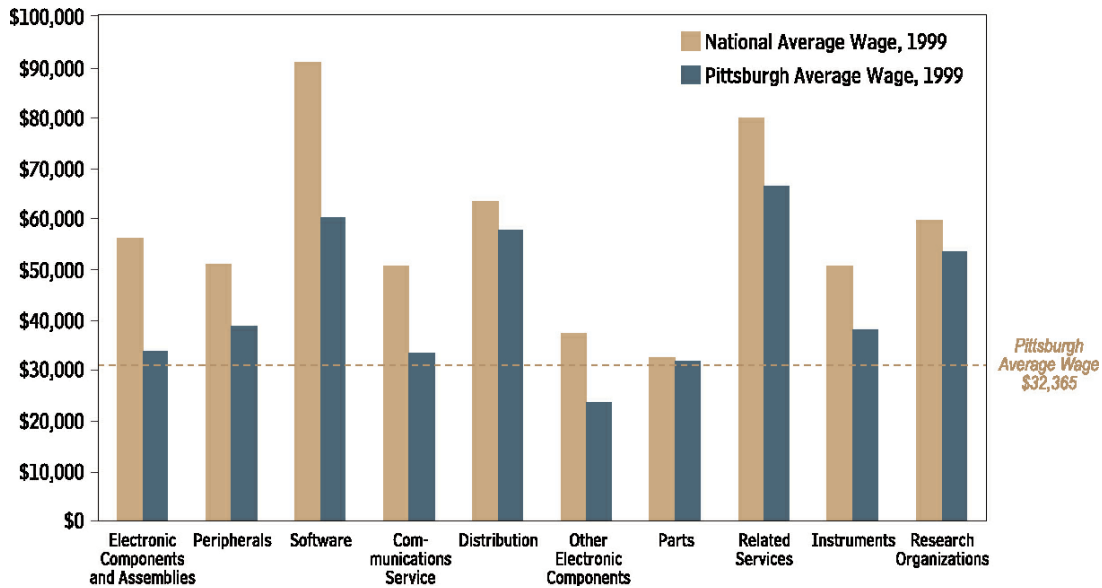
Economic Area	Total Employment 1999	% CAGR 1990-1999	% Share of National Employment 1999	Average Wages 1999	% CAGR of Average Wages 1990-1999
San Francisco-Oakland-San Jose, CA	144,920	2.0	17.1	\$99,262	9.6
Boston-Worcester-Lawrence-Lowell-Brockton, MA-NH-RI-VT	62,802	2.6	7.4	\$70,457	7.3
Los Angeles-Riverside-Orange County, CA-AZ	54,593	1.2	6.5	\$59,109	5.1
New York-No. New Jersey-Long Island, NY-NJ-CT-PA-MA-VT	49,968	-2.4	5.9	\$80,588	8.7
Austin-San Marcos, TX	33,844	9.3	4.0	\$66,123	7.6
Portland-Salem, OR-WA	33,762	12.5	4.0	\$63,699	5.0
Dallas-Fort Worth, TX-AR-OK	32,957	4.0	3.9	\$73,950	6.9
Minneapolis-St. Paul, MN-WI-IA	28,787	-0.1	3.4	\$52,111	6.5
Denver-Boulder-Greeley, CO-KS-NE	27,025	1.5	3.2	\$74,242	11.7
Phoenix-Mesa, AZ-NM	25,283	0.4	3.0	\$53,051	5.4
Washington-Baltimore, DC-MD-VA-WV-PA	23,842	2.7	2.8	\$83,860	8.3
Chicago-Gary-Kenosha, IL-IN-WI	22,886	9.1	2.7	\$66,113	7.4
Raleigh-Durham-Chapel Hill, NC	21,628	-0.3	2.6	\$64,927	5.6
Seattle-Tacoma-Bremerton, WA	20,307	14.1	2.4	\$148,441	17.4
Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD	16,278	6.2	1.9	\$59,404	5.8
Pittsburgh, PA-WV (35th)	4,542 (35th)	4.7 (80th)	0.5 (35th)	\$52,709 (47th)	4.3

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

Average Wages. In 1999, the average wage in the Pittsburgh MSA IT cluster (broad definition) was \$55,345, versus \$55,389 for the nation.⁸⁴ This increase from its 1990 level of \$34,159 was an annual growth of 5.5%, versus the nation's rate of 5.3%. The wage increase improved Pittsburgh's ranking from 96th to 67th highest paying cluster in the country over the 1990 to 1999 period.⁸⁵

Of the ten Pittsburgh subclusters for which wage data is available (Exhibit 69 on next page), all have lower wages than the national average in 1999. Software, which is the largest subcluster and the second highest paying in the region, had only 70% of the national software wage level.

Exhibit 69: Pittsburgh Information Technology Broad Cluster Subcluster Average Wages, 1999



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

Patents. In 1998, local information technology firms generated 72 patents, or 3.6 patents per 1,000 workers. Pittsburgh’s national ranking in patents per employee dropped from 51st in 1990 to 123rd in 1998. This level is well below the national average of 7.9 patents per 1,000 workers, and below top regions such as San Jose (10.6 per 1,000 workers), Austin (18.7 per 1,000 workers), or Boston (4.3 per 1,000 workers).⁸⁶ Patent production in Pittsburgh has been growing very slowly, at a 2% annual rate from 1990 to 1998. This is slower than each of the 20 largest clusters, all of which are growing from a larger base (see Exhibit 70).

While Pittsburgh’s share of national employment increased by 15% to 0.7, its share of the patent market decreased by more than 50% to 0.5. Although it appears that the region’s innovation level might be stagnating, it is important to point out that information technology funding has increased significantly in the past two years, while corresponding data for patents, particularly for software, is not available. This is in part due to patents for software not being registered by the U.S. Patent and Trademark Office until after 1996, when it adopted its Final Computer Related Examination Patent Guidelines. These guidelines are designed to assist patent examiners in handling hardware and software related inventions, and set the stage for software patenting under unique guidelines.

Exhibit 70: Establishments and Patents in the Twenty Largest Information Technology Clusters, Metro Area, Broad Cluster Definition

Metropolitan Statistical Area	Total Establishments 1999	CAGR of Total Establishments 1990-1999	Total Patents 1988	CAGR of Patents 1990-1998	Patents per 1,000 Employees 1998
San Jose, CA	4,195	8.0	2,231	0.24	10.6
Boston-Worcester-Lawrence-Lowell-Brockton, MA-NH	5,443	7.5	745	0.08	4.3
Washington, DC-MD-VA-WV	4,449	9.1	260	0.11	2.2
Chicago, IL	5,021	8.1	461	0.11	4.2
Los Angeles-Long Beach, CA	5,071	5.7	364	0.08	3.9
Dallas, TX	2,700	7.8	547	0.15	6.0
Orange County, CA	3,004	6.8	230	0.13	2.9
San Diego, CA	2,016	9.3	268	0.11	4.3
Atlanta, GA	3,069	12.2	170	0.21	3.0
New York, NY	4,274	8.5	352	0.13	6.9
Philadelphia, PA-NJ	2,636	6.7	162	0.09	3.1
Minneapolis-St. Paul, MN-WI	2,561	9.8	275	0.10	5.5
Austin-San Marcos, TX	1,023	11.6	862	0.30	18.6
Oakland, CA	2,407	11.5	461	0.22	8.7
Phoenix-Mesa, AZ	1,639	8.9	389	0.18	8.2
San Francisco, CA	2,161	8.5	467	0.23	10.2
Seattle-Bellevue-Everett, WA	2,016	9.3	386	0.23	9.2
Raleigh-Durham-Chapel Hill, NC	1,051	12.5	239	0.25	5.5
Portland-Vancouver, OR-WA	1,275	9.3	375	0.21	8.6
Nassau-Suffolk, NY	1,967	5.4	125	0.08	3.5
Pittsburgh, PA	833	7.18	71,530	0.02	3.6

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

Exhibit 71: Establishments and Patents in the Fifteen Largest Information Technology Clusters, Economic Area, Narrow Cluster Definition

Economic Area	Total Establishments 1999	CAGR of Establishments 1990-1999	Total Patents 1988	CAGR of Patents 1990-1998	Patents per 1,000 Employees 1998
San Francisco-Oakland-San Jose, CA	2,140	8.7	2,346	26.4	16.0
Boston-Worcester-Lawrence-Lowell-Brockton, MA-NH-RI-VT	1,275	8.3	501	10.4	7.7
Los Angeles-Riverside-Orange County, CA-AZ	1,590	6.3	395	12.2	7.3
New York-No. New Jersey-Long Island, NY-NJ-CT-PA-MA-VT	1,929	7.7	879	14.7	18.7
Austin-San Marcos, TX	228	10.5	690	33.6	23.3
Portland-Salem, OR-WA	318	9.4	314	25.8	8.5
Dallas-Fort Worth, TX-AR-OK	650	8.9	338	18.1	9.1
Minneapolis-St. Paul, MN-WI-IA	466	8.7	196	12.6	7.8
Denver-Boulder-Greeley, CO-KS-NE	616	9.2	291	24.2	11.9
Phoenix-Mesa, AZ-NM	341	11.8	209	22.1	8.2
Washington-Baltimore, DC-MD-VA-WV-PA	790	8.9	151	10.6	6.9
Chicago-Gary-Kenosha, IL-IN-WI	787	10.3	187	11.8	8.1
Raleigh-Durham-Chapel Hill, NC	179	13.3	126	26.8	5.8
Seattle-Tacoma-Bremerton, WA	485	10.8	319	30.6	17.8
Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD	470	9.3	108	9.7	6.2
Pittsburgh, PA-WV (35th)	169 (25th)	10.8 (74th)	39 (31st)	6 (123rd)	8.2 (70th)

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

The results are marginally better when we look at the economic area, narrow cluster definition (see Exhibit 71). At 8.2 patents per 1,000 workers, the Pittsburgh IT cluster is competitive with top regions. But again, patent growth is very slow; slower than each of the 20 largest clusters.

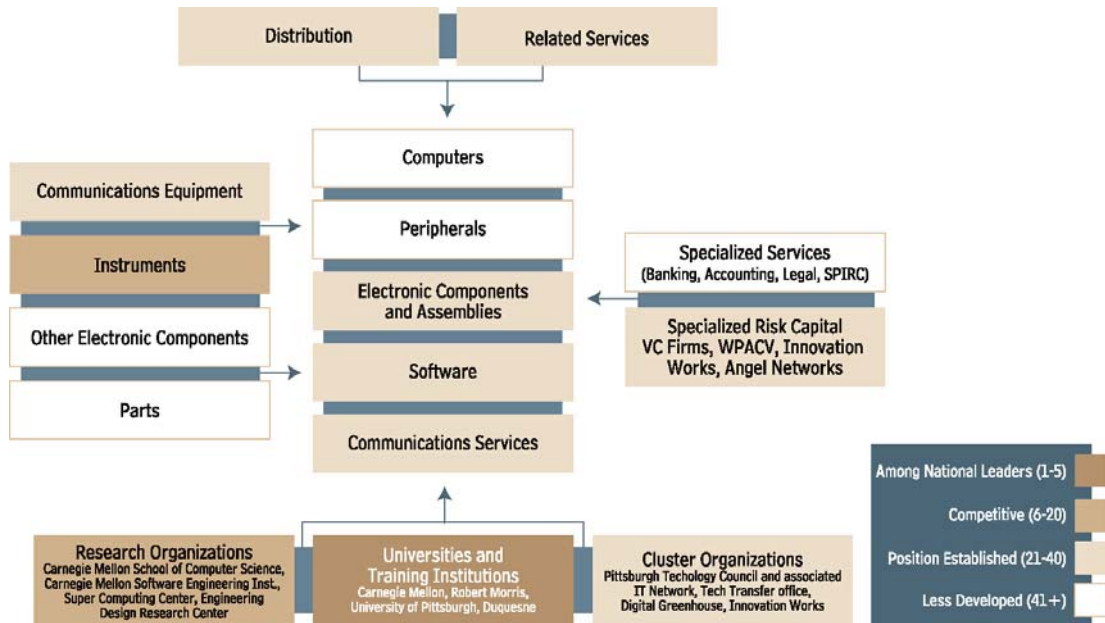
Establishments. We use establishment growth as a proxy for new firm formation (see Exhibit 71). Establishments in the MSA grew at a rate of 7.2% annually from 1990 to 1999. This was slower than 16 of the top 20 regional clusters (all of which are growing from a significantly larger base number of establishments). The EA/narrow cluster definition does better (primarily due to the shift to a narrow definition focus), with a growth rate of 10.8% being faster than 15 of the top 20 clusters.

Venture capital funding. According to the PriceWaterhouseCoopers Money Tree database, Pittsburgh regional software firms raised \$176 million in venture capital funds from 1995 through the third quarter of 2000. This was only 0.6% of the total VC funding for software. Pittsburgh has .87% of total software employment in the United States.⁸⁷ Boston accounted for 10.8% of software VC investments, and Austin received 1.7%.

DESCRIPTION OF THE REGIONAL INFORMATION TECHNOLOGY CLUSTER

Exhibit 72 depicts the Pittsburgh information technology 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 subclusters present in the region, and their relative strength has been statistically assessed by the CMP.

Exhibit 72: Competitive Position of the Pittsburgh Information Technology Cluster, Economic Area



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

Local universities and training institutions are among national leaders. In addition, the instruments and research subclusters are nationally competitive. However, the cluster is weaker in terms of core subclusters such as computers, peripherals, other electronic components and parts, and specialized services. Interviews and surveys indicate specialized services and risk capital are also relatively weak. The cluster is young, has effective associations, but it appears that they are lagging in promoting effective networking.

Among the larger information technology employers are firms such as Marconi Communications (formerly FORE Systems) and FreeMarkets. Several information technology firms, such as Black Box Corporation, iGATE, ANSYS, and FreeMarkets are among the ten largest firms among publicly held revenue-generating firms in the region. The fastest growing company list in the region is dominated by information technology, which represents 11 of the top 20 fastest growing firms in Pittsburgh.⁸⁸ The fastest growing company on the list was Stargate.net, an Internet service provider, with employment growth of 475% in 2000.

Exhibit 73 on the next page shows the relative size and growth of the industries in the Pittsburgh IT subclusters.

Exhibit 73: Pittsburgh's Information Technology Sub-Clusters and Industries, 1999

Subcluster	SIC	Industry	National Industry Share	Total Employment 1999	Employment CAGR 1990-1999
Total Cluster			0.7	20,008	5.2
Computers			0.1	60	-24.5
	3571	Electronic computers	0.1	60	-24.5
Electronic Components and Assemblies			0.3	946	-2.9
	3672	Printed circuit boards	0.4	303	0.0
	3674	Semiconductors and related devices	0.3	643	-4.1
Peripherals			0.3	344	19.3
	3572	Computer storage devices	0.1	60	22.0
	3575	Computer terminals	0.0	0	
	3577	Computer peripheral equip., n.e.c.	0.3	284	18.8
Software			0.9	2,650	17.9
	7372	Prepackaged software	0.9	2,650	17.9
Communication Services			0.5	212	0.6
	4820	Telegraph & other communications	0.9	6	-16.3
	4890	Communications services, n.e.c.	0.5	205	2.3
Distribution			0.6	4,350	0.8
	5045	Computers, peripherals and software-wholesale	0.7	3,057	2.2
	5065	Electronic parts and equipment-wholesale	0.4	1,293	-1.9
Other Electronic Components			0.3	513	-7.1
	7372	Prepackaged software	0.3	513	-7.1
Parts			0.3	524	-2.8
	3471	Plating and polishing	0.3	247	-5.9
	3671	Electron tubes	0.1	20	-11.5
	3676	Electronic resistors	0.0	0	-100.0
	3677	Electronic coils and transformers	0.7	117	31.5
	3678	Electronic connectors	0.0	10	
	3695	Magnetic & optical recording media	0.8	130	0.9
Related Services			0.7	2,600	9.5
	7375	Information retrieval services	0.4	409	9.9
	7376	Computer facilities management	0.4	233	2.6
	7377	Computer rental and leasing	0.8	114	4.0
	7379	Computer related services, n.e.c.	0.9	1,844	11.2
Instruments			3.6	1,917	4.6
	3826	Analytical instruments	3.9	1,358	5.5
	3827	Optical instruments and lenses	3.0	559	2.8
Communications Equipment			1.4	1,847	43.9
	3661	Telephone & telegraph apparatus	1.7	1,767	10.6
	3669	Communications equipment, n.e.c.	0.3	80	1.5
Research Organizations			1.3	4,046	10.6
	8731	Commercial physical research	1.3	3,044	8.9
	8733	Noncommercial research organizations	1.2	1,002	18.8

CLUSTER INNOVATIVE CAPACITY

The innovative capacity of the Pittsburgh IT cluster is strong in specialized inputs, but weaker in terms of commercialization mechanisms, levels of competition and collaboration, and the effectiveness of institutions for collaboration. Weaknesses in these areas of the diamond make it more difficult for strong factor inputs to lead to commercial success. This in turn leads to relatively poor economic performance and innovation output.

Specialized Research Centers. Information technology executives who responded to the survey are aware of a wide range of research centers in Pittsburgh but do not, or cannot, utilize them to their full potential. While nearly 80% of the top executives from our survey said local research centers were “readily available,” only 32% said these research institutions “frequently” transferred knowledge, and only 32% expressed satisfaction with the level of knowledge transfer to their industry (see Exhibit 74).⁸⁹ The satisfaction level with knowledge transfer in other regions ranged from 41% to 69%. Seventy-five percent of the surveyed executives state that the tech transfer offices are unhelpful. In the other regions studied, 47% to 59% said their technology transfer offices were unhelpful. Several interviewees also state that the tech transfer offices’ fees are prohibitively high.

Specialized educational institutions and talent pool. Pittsburgh has developed a strong academic and training infrastructure to support specialized studies in information technology fields. Carnegie Mellon started its computer curriculum in 1975 and established a school in 1988. Consequently, Pittsburgh is home to a high quality and large number of skilled information technology workers. According to the Bureau of Labor Statistics, in 1998 there were almost 13,000 computer scientists and more than 3,000 computer engineers, accounting for a combined 1.6% of the local workforce in the region. In the 2000 US News and World Report Graduate School Rankings, Carnegie Mellon Engineering School was ranked eighth in the country, and ninth for undergraduate engineering. The Computer Science School is ranked third. In addition, more than 70% of the interviewed executives felt that advanced educational programs provide their firms with high-quality employees.

Despite this, several Pittsburgh executives report concern about future access to labor. Approximately 40% of the executives we surveyed believe that the supply of scientists and engineers in the region is scarce for meeting the expansion needs of information technology cluster firms.⁹⁰ The concern for skilled labor is even greater, as 58% of the surveyed business leaders state that the available pool of skilled workers is too small and hinders growth. According to survey respondents, the greatest threat to future business success is available skilled labor. In addition, issues that senior executives voiced in the interviews focused on their inability to attract top management, in particular, marketing expertise. Several executives felt that this is compounded by the current perception of Pittsburgh as not progressive. As one executive stated, “We need out-of-area human resource capital. We need to market Pittsburgh and it’s the job of everybody.”

Sophistication of regional demand. Pittsburgh information technology executives express neutral to negative views about the level and sophistication of interaction with the firms in their local customer base. Only 36% of the respondents believe that their regional customers are sophisticated and have special needs that spur innovation. The range for other regions is 56% to 70%. Fifty-five percent of the information technology respondents state that their regional client feedback is infrequent.⁹¹ The range for respondents in other regions is 16% to 27%. A software development firm that is targeting the national market felt that local customers were no different in their business requirements from firms outside the

Exhibit 74: Major Information Technology Research Institutes in Pittsburgh

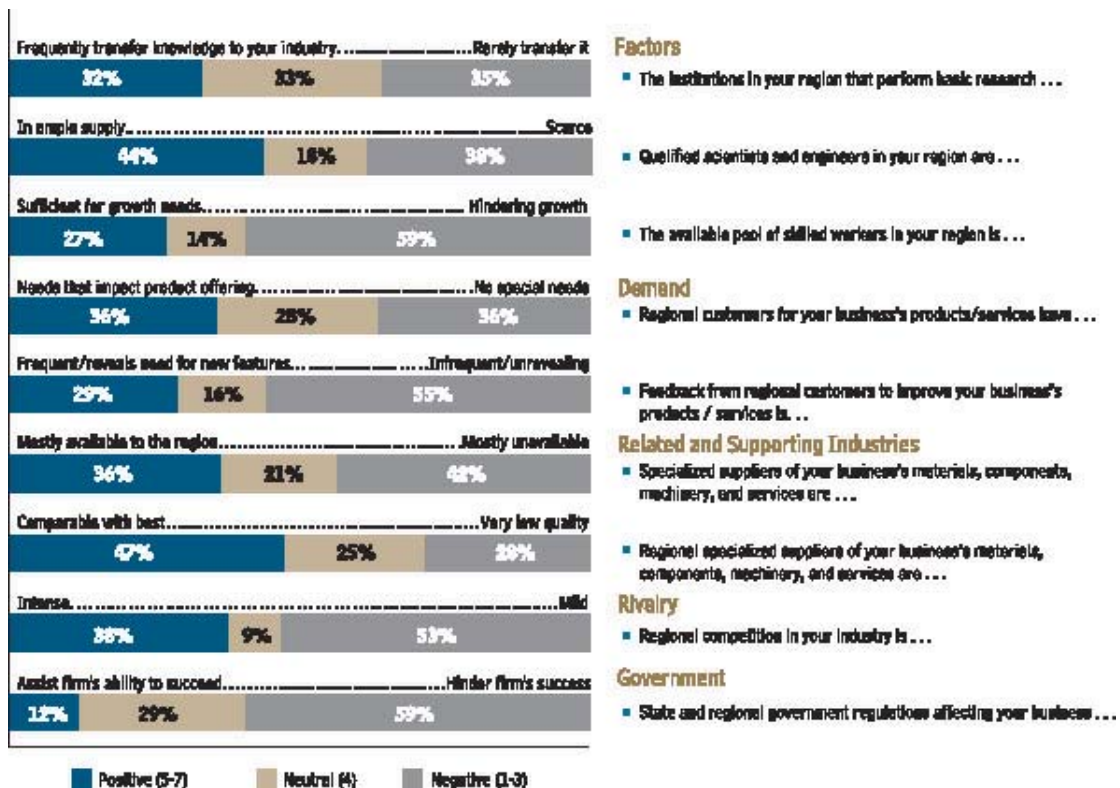
Institution	Focus
The Information Technology Center	Facilitates the development, transition, and insertion of advanced information technology
Pittsburgh Supercomputing Center	Carnegie Mellon University in consultation with the University of Pittsburgh and with the assistance of Westinghouse Electric Company
Software Engineering Institute	Federally funded research and development center
Carnegie Mellon University — Andrew Consortium	Carnegie Mellon University School of Computer Science, research group has a leading software system
Software Industry Center	University-based research center, explores how the software industry will develop and grow
The Entertainment Technology Center	Computer science and fine arts research center
Data Storage Systems Center	University-based research and education program in magnetic and magneto-optic recording technology
Center for Financial Analysis and Securities Trading	(FAST) seeks to integrate the technology and analytics of today's global financial markets
Institute for Complex Engineered Systems <ul style="list-style-type: none"> • The ERIS Lab • Advanced infrastructure Systems 	Research for software and computing technologies, reliable embedded systems, distributed real-time computing, and new paradigms
Engineering Design Research Center	Studies how design can be improved by computer software, operates four consortia: the Computer-Aided Process Design Consortium, the Rapid Product Manufacture Consortium, the Green Design Initiative, and the Building Computer-Aided Design Consortium

area. Another started his business by driving to New York to meet clients and currently less than one percent of his clients are in the Pittsburgh region. IT executives do not see local demand as a critical factor that provides a unique advantage to cluster firms.

Related and supporting industries. Pittsburgh executives who were surveyed are only moderately satisfied with their access to specialized suppliers and do not think regional suppliers provide the cluster firms with a particular competitive advantage. One software firm that was interviewed has 20 partners but only one was local. More than 40% of the survey respondents stated that specialized suppliers are not available in the region. The range in other regions is from 26% to 42%. Slightly more (47%) state that the local suppliers are comparable to the best suppliers elsewhere. However, the range for other regions was 65% to 66%. Finally, information technology executives do not rank their suppliers as valued partners in the development of new products. Thirty-three percent of the information technology managers consider their specialized suppliers as frequent contributors to their innovation effort, which was lower than the range of 34% to 45% in other regions.²²

Context for firm strategy and rivalry. Local competition in the Pittsburgh information technology cluster is not especially developed. Only 38% of the executives surveyed classified the level of local rivalry as “intense.” The range in other regions is 43% to 71%. Furthermore, it seems that the greatest degree of competition is for recruiting, as 65% believe that firms are worse off when they compete to attract and

Exhibit 75: Select Survey Results from Pittsburgh Information Technology Executives



Source: Clusters of Innovation Initiative Regional Survey™

retain skilled workers. Within the engineering base of potential employees, Pittsburgh is competing with other regions such as Boston, Austin, Seattle, and the San Francisco Bay Area to recruit and retain the talent necessary to sustain its growth.

Cluster attitudes of Pittsburgh information technology executives appear positive, as 73% state that firms in the cluster are better prepared to compete than isolated firms, and 77% believe competition increases productivity and that it is possible to compete and collaborate simultaneously. While the concepts of competition are viewed favorably, actual collaboration is not seen as effective. Seventy percent of information technology executives report that firms and organizations rarely contribute to cluster-wide programs, compared to 37% to 46% in other regions. Forty-three percent of industry executives state that cluster firms hide information from other firms; the range is only 21% to 31% in other regions. In addition, several interviewees indicate that Pittsburgh still has remnants of the old steel mentality, which inhibits the risk taking generally associated with the new technology culture.

Government. Federal government funding of university R&D, and of college and university training, have been especially helpful for the growth of the information technology cluster in Pittsburgh. The State government has created a wide array of programs such as Innovation Works, Technology 21, and its networking efforts. County government is active as an enabler by taking a pro-business stance. At the municipal level, the city has an agenda of downtown renewal, but fragmented governments make it difficult to create a cohesive policy.

Local business leaders are hoping to create industrial parks that would foster collaboration within and across clusters. However, information technology interviewees see local government as providing little support for these efforts. This appears to be changing at the county level, as almost all interviewees spoke highly of the efforts of Jim Roddey, the County Executive,⁹³ who consolidated county business development offices, improved efficiency, and continues business and community meetings to push regional economic development.

Among the information technology executives in our survey, the most important priorities for the government in the next five years are providing world-class primary and secondary education (94%), strengthening the communication/ information infrastructure (88%), improving the transportation infrastructure (88%), providing education and training programs (82%), and enhancing strong intellectual property laws (82%).

Institutions for collaboration. Despite a wide array of organizations such as the Chamber of Commerce, the Pittsburgh Technology Council and its Information Technology Network, linkages for networking appear underdeveloped. Several interviewees state that there are too many organizations with uncoordinated agendas. Only 27% of information technology executives state their cluster associations were effective, versus 39% to 60% for other regions. Seventy-three percent state that firms and organizations in the cluster infrequently share information, versus 35% to 49% in other regions. Only 21% state research institutions frequently transfer knowledge versus 41% to 69% in other regions. Finally, they believe that university networks and tech transfer offices and economic development organizations are either somewhat or not helpful. When measuring how helpful specific types of organizations are to these executives, national organizations fared the best (see Exhibit 76), but almost half the respondents also state that regional cluster councils are helpful a level almost double other regional players – a result most likely due to continued efforts of the Pittsburgh Technology Council.

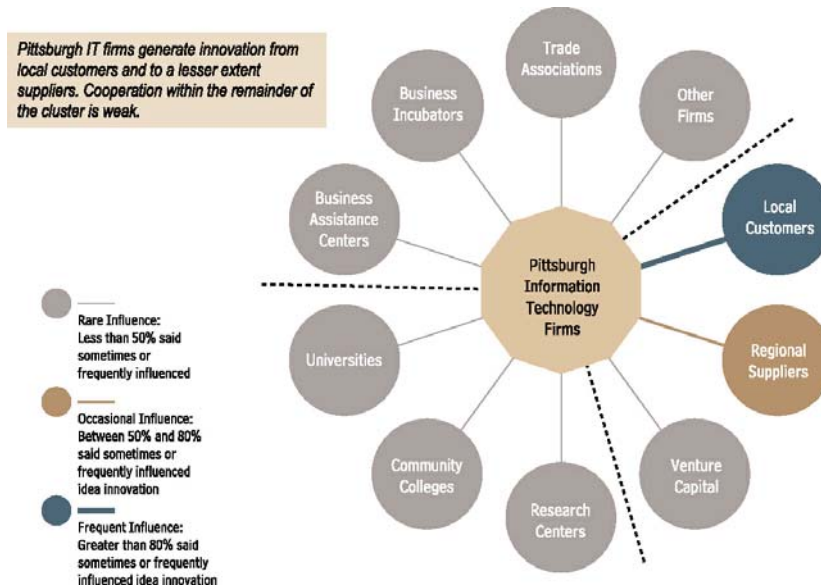
Exhibit 76: Select Survey IT Results on Pittsburgh’s Institutions for Collaboration

	Percent Reporting Helpful		Percent Reporting Unhelpful	
	Established	Entrepreneurial	Established	Entrepreneurial
National Trade Associations	56%	54%	44%	46%
Economic Development Organizations	26%	24%	74%	76%
University-based Networking Organizations	34%	33%	66%	67%
Regional Industry or Cluster Councils	50%	45%	50%	55%
University Technology Transfer Offices	25%	24%	75%	76%

Source: Clusters of Innovation Initiative Regional Survey™

We also asked survey respondents how frequently they interacted with other members of the cluster at the idea generation, product development, and commercialization stages of the innovation process. In Pittsburgh, information technology firms are much more likely to generate new ideas on their own than they are to jointly develop or commercialize an idea, as approximately 70% of firms do the majority of their idea generation and commercialization processes. When information technology firms generate new ideas, more than 80% tend to use input from customers and approximately 60% state they use other firms, universities, and suppliers (Exhibit 77). For commercialization, 80% of the executives say that customers provide useful feedback and suppliers provide 50% of the firms with useful feedback.

Exhibit 77: Frequency of Interaction among Information Technology Cluster Members on Idea Generation



Source: Clusters of Innovation Initiative Regional Survey™

CONCLUSION

Economic performance and innovation output of the Pittsburgh IT cluster are not strong. Growth has been sufficient to roughly maintain the cluster position as about the 30th largest in the country, but average wages and wage growth lag other regions. Moreover, innovation as measured by patents, establishment growth, and venture capital investments is low.

The Pittsburgh IT cluster can become competitive due to a number of strong assets including local universities with strength in computer sciences, high levels of R&D funding, many specialized research centers, and a large pool of talent. The cluster also has a model cluster-specific institution for collaboration in the Pittsburgh Digital Greenhouse. Although the PDG's focus is too narrow to significantly help the broader cluster, it can serve as an example for an institution targeting all cluster members.

The main challenges accounting for poor cluster performance are relative weakness in core subclusters (e.g., computers, peripherals, components, software, and communications services), low levels of competition and collaboration among firms, and infrequent contact with suppliers and customers.

Pittsburgh's information technology cluster is an instructive case for several reasons. First, it shows that high-quality specialized inputs, for example, R&D funding and talented scientists and engineers, are instrumental to the development of a cluster. These assets are what makes Pittsburgh a viable contender in this market. Second, it is important to connect people doing basic research with people who know how to start companies and to provide them regional access to funding organizations. This has had mixed results in Pittsburgh. The industry gained momentum as university professors started firms and helped to retain and attract a regional base of talent – but most executives feel that networking, commercialization, attracting talent and providing funding can be improved. Third, all the elements of the diamond must be developed and reinforced. This includes developing regional demand and specialized segments, regional organizations, regional suppliers, and related industries. As these are developed, they can assist to unlock the power of the cluster and its network of associations, and the universities with their associated high levels of research and development.

THE PRODUCTION TECHNOLOGY CLUSTER IN PITTSBURGH

Nationally, the core of the production technology cluster is composed of industries that design, manufacture, and sell equipment, vehicles, metalwork, machine tools, and metal processing. The cluster also includes suppliers of specialized inputs, such as abrasive products. Related components in the cluster include metal manufacturing, such as blast furnaces, special dies, metal stampings and general industrial machinery; and industries that provide related equipment such as analytical instruments and measuring and controlling devices. Finally, each region has various related industry organizations, educational institutions, and government agencies playing important roles.

Detroit and Chicago have the largest production technology cluster by a large margin, with 124,000 and 97,000 workers respectively in 1999. Other important metropolitan areas include Cleveland, Boston, and St. Louis. Yet production technology employment in the United States has contracted at an annual rate of 0.4% from 1990 to 1999. Detroit and Chicago contracted by 2.4% and 1.1% annually.

Production technology in Pittsburgh has fared slightly better than these major markets. There were 35,600 workers in the cluster in 1999, down from 35,900 in 1990. This was an annual contraction rate of 0.1% from 1990-1999, which increased the Pittsburgh production technology cluster from tenth largest to eighth.⁹⁴ Wages in the Pittsburgh cluster have grown by 1.9% annually, but that dropped its rank from the seventh highest paid region to 43rd. Its performance in terms of patent registration is still above average for the nation, but has been declining relative to other regions.

Exhibit 78: Economic Performance and Cluster Composition of the Production Technology Cluster

Economic Performance and Innovation Output	Cluster Composition and Business Environment
<ul style="list-style-type: none"> ■ Employment 1999 employment is near 35,600 at the 8th largest in nation—improving from 10th in 1990 ■ Wages Average wage was \$42,600 in 1999, 1.9% annual growth in the 1990-1999 period decreasing national rank from 7th to 43rd ■ Patents Patents per employee dropped from 3.3 in 1988 to 3.1 in 1998; dropping it from 159th to 205th nationally ■ Establishment Growth Establishments grew 1.3% annually during the 1990 to 1999 period ■ Venture Capital Investments VC reached \$10 million between 1995 and 2000; below other markets in our study; but a new \$50 million fund rolls out in 2001 	<ul style="list-style-type: none"> ■ Cluster stabilizing after the recession and steel industry fallout of the 1980s ■ Skilled labor with many training programs—but youth drain could have negative impact on cluster ■ No strong cluster ties—only moderate with other firms, suppliers and customers; institutions for collaboration receive weak scores for effectiveness, large firms work with universities ■ Small tool and die firms and broader cluster specialty steel firms show mild resurgence in 1990s ■ Few effective organizations in cluster: SPIRC, Pittsburgh Technology Council ■ Robotics and other technology cross-cluster innovations have potential to improve prosperity

Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School; PriceWaterhouse Coopers Money tree database

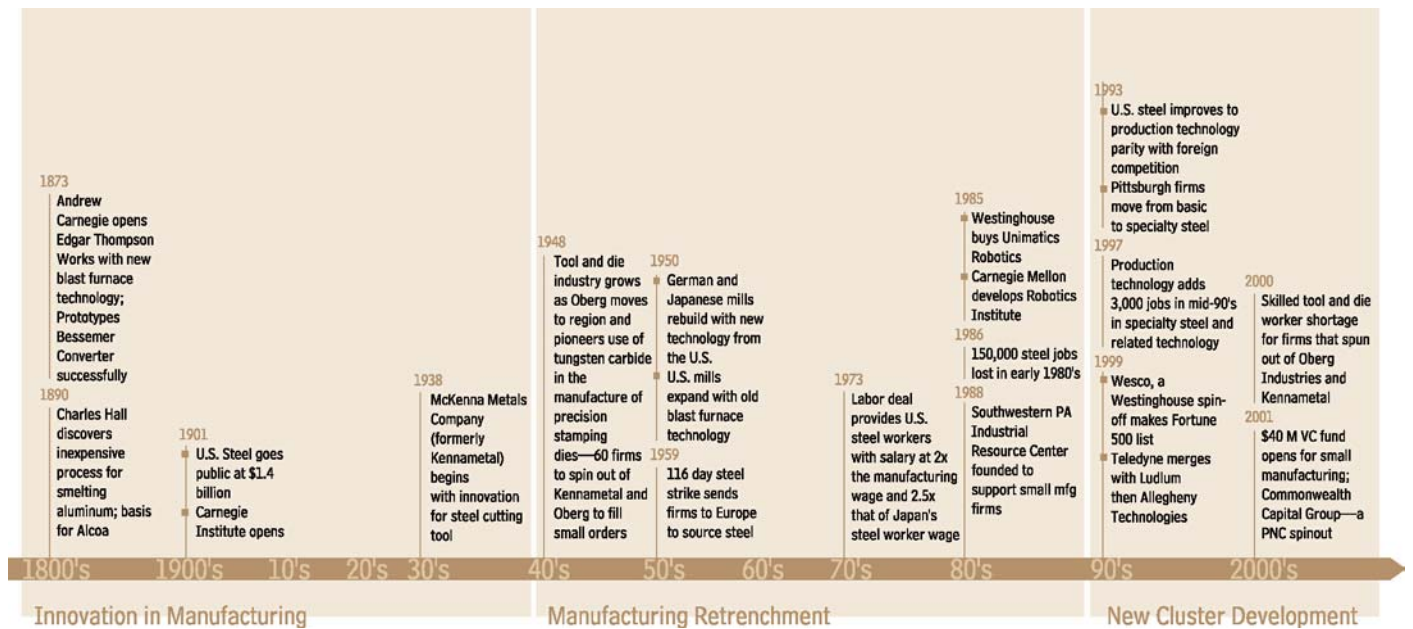
Pittsburgh’s production technology cluster developed primarily by supplying equipment and technology to steel companies. Basic steel dominated the cluster until the 1980s. Even today, almost half of the cluster consists of steel workers (roughly 15,500 employees in 1999).

DEVELOPMENT OF PITTSBURGH’S PRODUCTION TECHNOLOGY CLUSTER

The production technology cluster in Pittsburgh developed with the rise of steel in the area. Abundant coal, low cost ore, proximity to the world’s largest demand, and good rail and water transportation encouraged steel production in southwest Pennsylvania. But so too did production technology innovations. A catalytic moment in Pittsburgh’s production technology history occurred in 1873, when Andrew Carnegie’s use of a new production technology – the Bessemer Converter - helped to accelerate growth of Pittsburgh’s production technology and metal manufacturing clusters. Near the turn of the century, Pittsburgh firms generated a number of innovations, including George Westinghouse’s 360 patents, and Charles Hall’s high-grade aluminum, which was the basis for Alcoa.

This set the stage for the production technology cluster in two ways. First, these large firms created their own production technology – and Carnegie was known to stop production for weeks to build new innovations for steel production. Second, it attracted other firms such as McKenna Metals (now Kennametal) in 1938 and Oberg Industries in 1948 that supplied the steel industry with technology, cutting tools, and so forth. These early tool and die firms acted as anchors for the cluster by spinning out more than 60 firms in the region, such as U.S. Tool and Die, Reunion Industries, and Parker Hannifin.

Exhibit 79: Pittsburgh Production Technology Key Events Timeline



Source: Interviews

Although the production tech cluster in Pittsburgh diversified somewhat after World War II—with the entrance of firms such as Kurt J Lesker (vacuum products, 1954), Aerotech (precision motion components, 1970), and Adtranz (railcar production, 1970s)—steel dominated the cluster until its retrenchment in the 1980s. When German and Japanese firms rebuilt their factories after World War II, they introduced new production technologies such as continuous casting and basic oxygen furnaces. Oxygen furnaces, which were developed in the United States during the 1930s, reduced the time to heat steel from six hours to 40 minutes, allowing cost reductions from \$35 to \$15 per ton compared to open-hearth technology.⁹⁵ In addition, the United States spent \$1.4 billion on assisting Europe and Japan’s steel industry to build this technology.⁹⁶ In the 1950s, it took Japanese workers three times longer than their American counterparts to produce a given amount of steel. Then, Japanese efficiency surpassed the United States in 1972, and was ahead 5.4 to 4.4 in the early 1980s.

U.S. steel makers had overestimated the costs and underestimated the benefits of the new technologies in the 1950s. At that time, U.S. capacity was expanded by 50% using the 100 year-old blast furnace technology. Their failure to innovate cost U.S. steel companies dearly. It was not until the early 1990s all production in the United States was either oxygen or electric furnaces.⁹⁷

A second problem was created by the desire of avoiding the crippling strikes that occurred in the 1940s and 1950s. These strikes led purchasers to source steel from outside the United States. The result was that labor costs rose through the 1970s, and even more purchasers turned to global markets. As U.S. firms responded by sourcing steel from Europe and Japan, imports as a percent of production climbed from less than 0.1% in the early 1950s to more than 26% in 1984.⁹⁸ The result was that 150,000 steel industry jobs were lost in Pittsburgh. While the United States had mostly stable employment in manufacturing from 1969 to 1992, Allegheny County and the Pittsburgh MSA had almost a steady decline. From 1969 to 1992 manufacturing jobs as a share of non-farm jobs declined from 25% to 9% in Allegheny County, due primarily to the loss of the steel industry jobs.

Four trends developed from the onslaught of foreign competition, which helped to improve productivity in the region’s related production technology cluster. The first occurred as investments in new technologies allowed U.S. firms to reach productivity parity with foreign firms by 1993. This coincided with a modest economic expansion in the United States, and the investments allowed U.S. firms to accelerate productivity, and to compete on profitability. In the last 15 years alone, the North American steel industry has spent more than \$50 billion to modernize facilities — with innovation resulting in lighter, stronger, cleaner, more recyclable, and less expensive steel.⁹⁹

Second, Pittsburgh firms began to focus on smaller specialty and mini-mills to serve niche markets.¹⁰⁰ This entailed simplifying the product and process mix, and increasing the output of higher value added products. This focus also helped reduce costs through technology investments and streamlining operations. The total cost per ton at most mini-mills in the United States was reduced to less than the freight cost of imports from Korea.¹⁰¹ Allegheny Technologies is an example of a firm that embraced this strategy.

Third, as the cluster experienced its downturn in the 1980s, supporting institutions assisted with the recovery. For example, Carnegie Mellon University began to generate both information technology and robotics research, which would have a positive impact on innovation in the cluster. Older financial institutions helped regional mills to invest in newer technology. In addition, North American steel producers,

suppliers, and affiliated organizations joined together in 1997 to form TheSteelAlliance, an industry-wide coalition that collaborates and promotes the industry to the public.

Fourth, the region became more business friendly, as organizations, unions, and the government attempt to improve the business climate. Universities work with large firms such as Allegheny Technologies to provide advanced training and degrees. VC funds are beginning to address the sector’s needs, albeit at a preliminary level. Unions are cooperating more, and by 1993, hourly compensation was equal to Germany’s and less than Japan’s. Although the cluster continued to decline through the early 1990s, it had a mild resurgence beginning in 1993, and eventually would grow by almost 3,000 jobs by 1997. This was led by employment increases in metal processing, casting and forging, and specialized input industries.

The production technology cluster has stabilized in Pittsburgh, despite losing employment during the past decade. Although many of the firms in the cluster are holdovers from the steel industry, other businesses in the production technology sector have helped the cluster to stabilize. For instance, Alcoa employs 1,700 in aluminum technology, Heinz, with 1,900 in food production and distribution, PPG industries has 3,000 in glass, fiberglass and coatings production, and G&G Investments, with 700 producing glass.¹⁰² In addition, more than 200 foreign firms have production facilities in or near Pittsburgh, such as Adtranz, with 1,300 employees producing railway vehicles; SONY, which added almost 4,000 jobs with its glass plant in the early 1990s and now has 3,000 employees in its New Stanton plant including the addition of American Video Glass in the early 1990s; and Bayer, which opened a plastics manufacturing facility in the 1970s.

Finally, the robotics sector is gaining momentum, which has some potential to help rejuvenate the cluster. A catalytic event for robotics occurred when Westinghouse bought Unimation in the mid-1980s, generating both regional interest and interest at Carnegie Mellon University. Carnegie Mellon then founded the Robotics Institute and successfully brought in federal funding. In addition, an array of robotics research groups have developed, such as Services Robotics, Industrial Robots, Redzone, and Customized Systems.

Exhibit 80: Pittsburgh Production Technology Innovation Environment Measures

Historical Obstacles	Important Enablers	Key Events
<ul style="list-style-type: none"> ■ Fractured local geo-political structure ■ Quality of life poor and dangerous when the mills were working at capacity ■ Heavy reliance on basic steel; with missed opportunity to upgrade technology in the 1950s 	<ul style="list-style-type: none"> ■ Strong work ethic among locals – great local reputation among half a dozen technical schools and universities ■ War support and/or strong economic growth periods ■ Long established iron and steel, aluminum, appliance and food processing firms moderately strong supplier network ■ Universities create engineering/ tech programs with funding from steel industries, Carnegie, etc.) ■ 80 technical schools with 30,000 students 	<ul style="list-style-type: none"> ■ Foreign competition develops from Japan and Europe ■ Steel technology rebounds to parity with Japan and Germany in 1990, as mills focus on market niches ■ Fifteen of 19 Fortune 500 headquarters close or move. ■ In robotics, Westinghouse buys Unimation and begins robotics focus. CMU founds the Robotics Institute in mid 1980s. ■ Steel firms shift focus to specialty products

RECENT ECONOMIC PERFORMANCE

Our assessment of *current* economic performance of the Pittsburgh cluster shows that the steel component of the cluster is struggling with relatively slow employment growth and low wages. However, the core subclusters are doing well with relatively good employment growth, high wages, and strong wage growth. The main concern is that innovation levels—as measured by patents and VC funding—are very low. This is true for both the broad and narrow cluster definitions. This raises concerns about future prosperity for the cluster.

Employment. In 1999, there were more than 35,550 employees in the Pittsburgh MSA production technology cluster (broad definition; see Exhibit 81). This was 1.9% of total national employment in the production technology cluster and ranked Pittsburgh as the eighth largest production technology cluster

Exhibit 81: Employment and Average Wages in the Twenty Largest Production Technology Clusters, Metropolitan Statistical Area, Broad Cluster Definition

Metropolitan Statistical Area	Total Employment 1999	CAGR 1990-1999	Share of National Employment 1999	Average Wages 1999	CAGR of Average Wages 1990-1999
Detroit, MI	124,438	-2.4	6.7	\$54,615	3.9
Chicago, IL	97,082	-1.1	5.2	\$42,361	3.3
Cleveland-Lorain-Elyria, OH	59,427	-0.8	3.2	\$46,457	3.8
Milwaukee-Waukesha, WI	43,045	0.5	2.3	\$41,777	2.4
Los Angeles-Long Beach, CA	40,283	-2.5	2.2	\$39,086	4.0
Boston-Worcester-Lawrence-Lowell-Brockton, MA-NH	38,682	-0.9	2.1	\$47,612	4.4
Minneapolis-St. Paul, MN-WI	37,255	0.0	2.0	\$42,578	3.4
Pittsburgh, PA	35,552	-0.1	1.9	\$42,570	1.9
St. Louis, MO-IL	30,710	-0.6	1.6	\$40,952	3.7
Grand Rapids-Muskegon-Holland, MI	29,989	2.3	1.6	\$45,335	3.1
Gary, IN	29,203	-2.6	1.6	\$54,815	3.3
Dayton-Springfield, OH	25,889	0.6	1.4	\$42,041	2.8
Philadelphia, PA-NJ	25,856	-4.4	1.4	\$43,720	3.6
Youngstown-Warren, OH	22,582	-0.1	1.2	\$54,510	8.3
Houston, TX	20,646	3.9	1.1	\$36,964	1.5
Kansas City, MO-KS	18,793	2.9	1.0	\$43,756	4.4
Rockford, IL	18,399	-0.8	1.0	\$40,078	3.0
Flint, MI	18,195	1.3	1.0	\$51,569	7.4
Cincinnati, OH-KY-IN	18,171	1.1	1.0	\$38,735	3.8
Atlanta, GA	17,999	1.0	1.0	\$36,791	3.6

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

in the United States.¹⁰³ The region's 0.1% annual rate of contraction over the 1990 to 1999 period increased Pittsburgh's national rank from the tenth largest region in 1990. It should be noted that the cluster's lowest employment level was in 1993, after which it added more than 2,000 jobs by 1999. Growth occurred in metal processing; and casting and abrasive products.

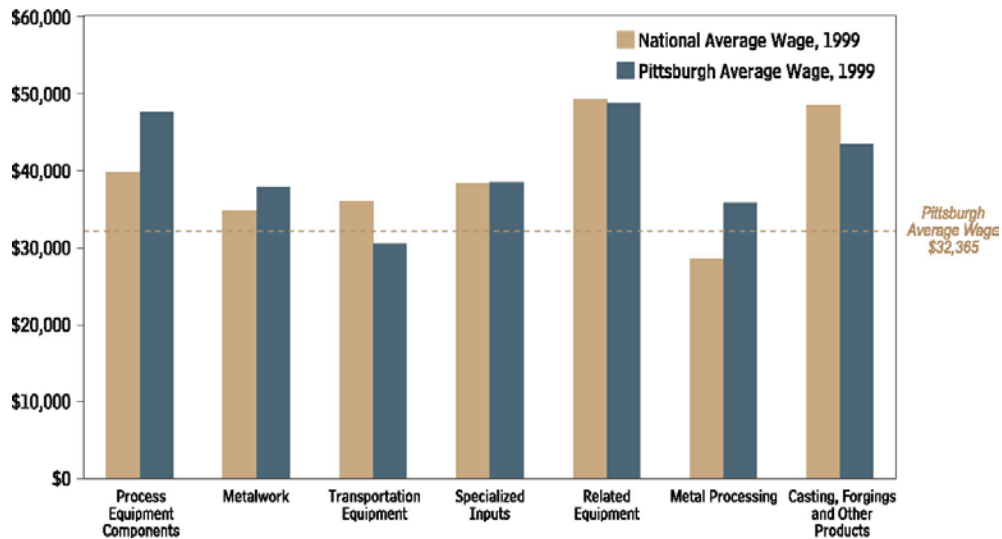
We also benchmark the Pittsburgh region using the economic area as the geography of reference, and using the narrow cluster definition (see Exhibit 82). The economic area is relatively accessible in a single working day, and so contains assets that are part of the cluster. The narrow cluster definition only includes subclusters that are the core of the cluster. Measured this way, Pittsburgh employs just fewer than 10,000. Its ranking for production technology drops from seventh to 20th. The reason is that much of the production technology employment in Pittsburgh is core to the metal manufacturing cluster (i.e., steel workers), and is excluded in the narrow definition of the production technology cluster. Though the narrow cluster is relatively weaker in absolute terms than the broad cluster, it has grown by 0.5%, faster than 10 of the largest 15 clusters.

Exhibit 82: Employment and Average Wages in the Fifteen Largest Production Technology Clusters, Economic Areas, Narrow Cluster Definition

Economic Area	Total Employment 1999	CAGR 1990-1999	Share of National Employment 1999	Average Wages 1999	CAGR of Average Wages 1990-1999
Chicago-Gary-Kenosha, IL-IN-WI	54,815	-0.5	8.0	\$41,010	3.2
Cleveland-Akron, OH-PA	40,629	-0.5	6.0	\$44,025	4.3
New York-No. New Jersey-Long Island, NY-NJ-CT-PA-MA-VT	36,639	-3.1	5.4	\$42,363	3.8
Los Angeles-Riverside-Orange County, CA-AZ	36,606	0.2	5.4	\$39,648	3.6
Detroit-Ann Arbor-Flint, MI	34,535	0.0	5.1	\$48,997	3.6
Boston-Worcester-Lawrence-Lowell-Brockton, MA-NH-RI-VT	29,195	-0.6	4.3	\$43,437	4.7
Milwaukee-Racine, WI	28,662	0.0	4.2	\$41,439	3.1
Minneapolis-St. Paul, MN-WI-IA	21,960	2.9	3.2	\$41,558	3.8
Dallas-Fort Worth, TX-AR-OK	15,939	2.0	2.3	\$35,032	3.7
Cincinnati-Hamilton, OH-KY-IN	15,277	0.1	2.2	\$36,911	3.6
Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD	14,427	-1.4	2.1	\$41,076	3.6
Houston-Galveston-Brazoria, TX	14,068	3.6	2.1	\$35,857	1.7
Indianapolis, IN-IL	11,275	0.2	1.7	\$42,936	5.3
Tulsa, OK-KS	10,972	6.7	1.6	\$36,435	2.3
Greenville-Spartanburg-Anderson, SC-NC	10,616	1.9	1.6	\$36,854	3.2
Pittsburgh, PA-WV	9,955 (20th)	0.5 (116th)	1.5 (20th)	\$41,683 (21st)	4.7 (13th)

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

Exhibit 83: Pittsburgh Production Technology Subcluster Average Wages, 1999



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

Average wages. In 1999, average wages in the Pittsburgh MSA production technology cluster (narrow definition) were \$42,570. This was lower than 10 of the 20 largest clusters. Pittsburgh production technology wages grew annually by 1.9% from 1990-1999, considerably slower than the national average of approximately 3.4%. Pittsburgh’s national pay rank dropped from seventh to 43rd over the period. The cluster has had a history of extremely high wages in the 1970s and 1980s, which was one of the factors that allowed foreign competition to gain market share.

The average wage for the narrowly defined cluster in the Pittsburgh economic area was \$41,683, higher than 10 of the 15 largest clusters. Wage growth, however, was 4.7%. Only one cluster in the top 15—Indianapolis—has a faster wage growth.

Four of the seven available subclusters currently have higher wages than their national averages, with process equipment subsystems and related equipment being the highest paid subclusters (see Exhibit 83).

Patents. In 1998, Pittsburgh production technology firms and institutions registered 110 patents (see Exhibit 84), representing 1.3% of total U.S. production technology cluster patents (recall the Pittsburgh MSA employs 1.9% of the national production technology labor force). This compares poorly to Detroit, Boston, and Chicago, at 5.1%, 3.7%, and 3.9% respectively. Patents per employee in Pittsburgh were 3.1 in 1998, lower than 9 of the 20 largest clusters (MSA, broad cluster definition). Annual growth in patents per worker was negative from 1990-1998. This was worse than 18 of the 20 largest clusters (MSA, broad cluster definition).

We use number of cited patents as a measure of the quality of patents. The production technology cluster in Pittsburgh lags the nation in terms of cited patents as well. It had 1.0 cited patents per 1,000 employees, which was less than half the national average of 2.2 for the cluster.

Exhibit 84: Establishments and Patents in the Twenty Largest Production Technology Clusters, Metropolitan Statistical Area, Broad Cluster Definition

Metropolitan Statistical Area	Total Establishments 1999	CAGR of Total Establishments 1990-1999	Total Patents 1988	CAGR of Patents 1990-1998	Patents per 1,000 Employees 1998
Detroit, MI	1,893	-0.5	443	0.04	3.5
Chicago, IL	2,036	0.1	338	0.03	3.4
Cleveland-Lorain-Elyria, OH	861	0.1	111	0.03	1.9
Milwaukee-Waukesha, WI	647	0.9	90	0.02	1.9
Los Angeles-Long Beach, CA	1,146	-1.8	235	0.03	5.6
Boston-Worcester-Lawrence-Lowell-Brockton, MA-NH	840	-0.4	326	0.05	8.0
Minneapolis-St. Paul, MN-WI	687	2.2	199	0.04	5.1
Pittsburgh, PA	390	1.3	110	-0.02	3.1
St. Louis, MO-IL	327	0.5	94	0.05	2.6
Grand Rapids-Muskegon-Holland, MI	472	2.8	58	0.07	1.8
Gary, IN	82	2.6	10	-0.03	0.3
Dayton-Springfield, OH	343	0.7	72	0.02	2.6
Philadelphia, PA-NJ	605	-0.8	135	0.00	5.1
Youngstown-Warren, OH	197	0.7	12	0.02	0.5
Houston, TX	555	4.3	229	0.02	11.5
Kansas City, MO-KS	190	1.1	35	0.07	2.2
Rockford, IL	241	2.1	27	-0.06	1.4
Flint, MI	55	-0.7	14	0.04	0.8
Cincinnati, OH-KY-IN	280	0.6	80	0.05	3.9
Atlanta, GA	275	2.6	109	0.08	5.5

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

Looking at the narrow cluster in the Pittsburgh economic area, the number of patents per employee was 6.3 in 1998, higher than 10 of the 15 largest production technology clusters (see Exhibit 84). Growth in patents per worker, however, is again negative. Only one of the top 15 clusters performed worse.

Establishments. We use establishment growth as a proxy for new firm formation (see Exhibit 70). Establishments in the MSA grew at a rate of 1.3% annually from 1990 to 1999. This was faster than 13 of the top 20 regional clusters (see Exhibit 83). The EA/narrow cluster definition also does well, with a growth rate of 2.4% being faster than 10 of the top 15 clusters (see Exhibit 85).

Exhibit 85: Establishments and Patents in the Fifteen Largest Production Technology Clusters, Economic Areas, Narrow Cluster Definition

Economic Area	Total Establishments 1999	CAGR of Establishments 1990-1999	Total Patents 1988	CAGR of Patents 1990-1998	Patents per 1,000 Employees 1998
Chicago-Gary-Kenosha, IL-IN-WI	1,017	1.57	219	2.0	3.7
Cleveland-Akron, OH-PA	593	0.49	103	3.0	2.6
New York-No. New Jersey-Long Island-NY-NJ-CT-PA-MA-VT	1,103	-0.38	386	1.0	9.9
Los Angeles-Riverside-Orange County, CA-AZ	925	-0.40	237	2.0	6.1
Detroit-Ann Arbor-Flint, MI	863	-0.59	205	2.0	5.6
Boston-Worcester-Lawrence-Lowell-Brockton, MA-NH-RI-VT	501	0.88	188	5.0	6.6
Milwaukee-Racine, WI	376	1.48	66	1.0	2.2
Minneapolis-St. Paul, MN-WI-IA	403	3.10	115	4.0	5.1
Dallas-Fort Worth, TX-AR-OK	342	2.55	103	4.0	6.3
Cincinnati-Hamilton, OH-KY-IN	171	1.11	59	6.0	3.5
Philadelphia-Wilmington-Atlantic City, PA-NJ-DE-MD	353	0.60	100	0.0	6.7
Houston-Galveston-Brazoria, TX	351	4.31	134	2.0	10.0
Indianapolis, IN-IL	184	0.73	47	5.0	3.7
Tulsa, OK-KS	190	4.55	26	-5.0	2.4
Greenville-Spartanburg-Anderson, SC-NC	95	4.63	27	5.0	2.6
Pittsburgh, PA-WV	204 (13th)	2.39 (104th)	59 (19th)	-2.0 (141st)	6.3 (65th)

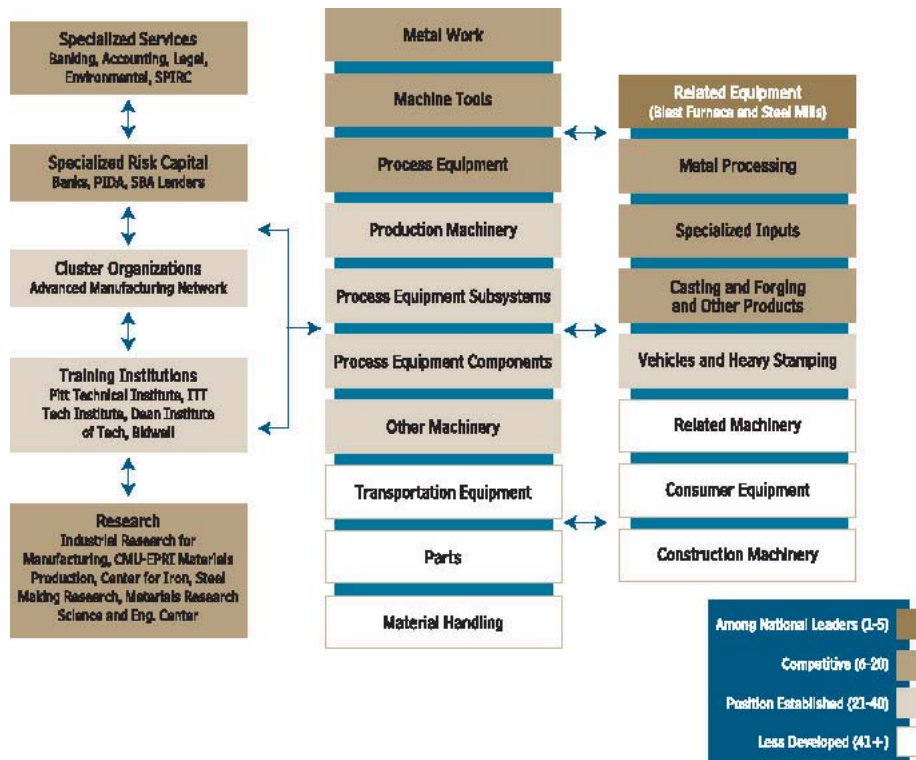
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School

Investments/VC funding. According to PriceWaterhouseCoopers Money Tree database, Pittsburgh industrial firms only raised \$10 million in venture capital funds with eight deals over the 1995 to 1999 period, or 1.32% of the national total over this period.¹⁰⁴ Of the eight venture capital deals in Pittsburgh, five were allocated to one firm, Axicom Technologies. There is some activity for three robotics firms and three other production technology firms through Innovation Works, but the amount of all these investments is just over a million dollars. This may change as a new VC firm that spun out of PNC Bank with \$40 million is available to focus on manufacturing and production technology.

DESCRIPTION OF THE REGIONAL PRODUCTION TECHNOLOGY CLUSTER

Exhibit 86 depicts the relative strength of subclusters in the Pittsburgh production technology 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 subclusters present in the region; their relative strength has been statistically assessed by the CMP.

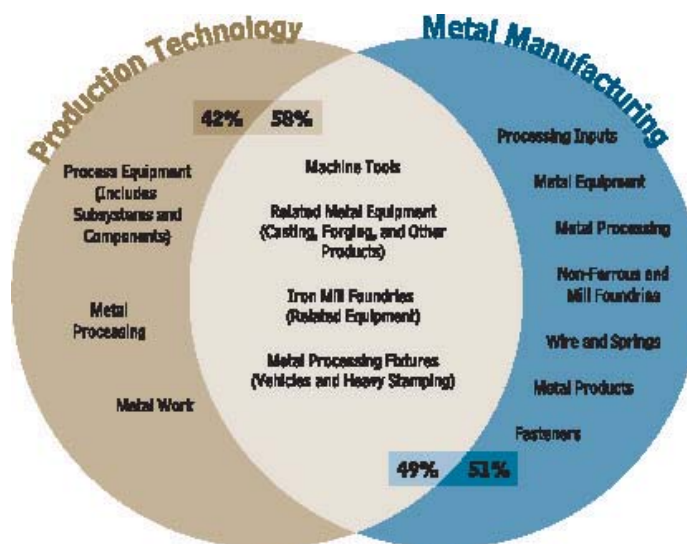
Exhibit 86: Competitive Position of the Pittsburgh Production Technology Cluster, Economic Area



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

The cluster is particularly strong in related equipment, which includes blast furnaces and steel mills. Subclusters closely related to steel, such as metal work, machine tools, process equipment, metal processing, casting and forging, and specialized inputs are nationally competitive. So too are specialized services, specialized risk capital, and research. Weaker subclusters (e.g., process equipment subsystems and components, other machinery, vehicles and heavy stamping, transportation equipment, etc) are less closely related to steel.

Exhibit 87: Pittsburgh Production Technology versus Metal Manufacturing
(subclusters employing over 1,000)



Notes: In parentheses is production technology subcluster name. Metal Processing redundancy is less than 10%. Steel mills (Mill Foundry) comprise over 1/3 of metal manufacturing employment and almost 1/2 of production technology employment; percents include all cluster employment
Source: Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School; [Sub Clusters with EA Employment Over 1,000](#)

As Exhibit 87 indicates, four of the 16 subclusters with a workforce of more than 1,000 are located in both production technology and the metal manufacturing subcluster. One of these four subclusters, Iron Mill Foundries, comprises over one-third of the metal manufacturing cluster and almost half of the production technology cluster. The two clusters are tightly intertwined and both developed primarily as part of, and due to the support and leverage of the steel industry in Pittsburgh.

Exhibit 88 shows the relative size and growth of the subclusters and industries within Pittsburgh production technology cluster. The Pittsburgh production technology cluster includes firms in design, manufacturing and selling equipment, vehicles, metal processing, metalwork, and tools. The largest subclusters are related equipment, vehicles and heavy stamping, process equipment, metal processing, and castings. Among subclusters with more than 1,000 employees, four experienced positive annual growth during the period, including metal processing (9.0%), machine tools (4.3%), process equipment components (4.3%), and castings (2.8%). The two largest, related equipment and vehicles/heavy stamping, have been shrinking at respective annual rates of 1.7% and 2.2%.

Exhibit 88: Pittsburgh Production Technology Cluster Industries

Subcluster	SIC	Industry	National Industry Share	Total Employment 1999	Employment CAGR 1990–1999
Total Cluster			1.9	35,552	-0.1
Machine Tools			1.3	1,212	4.3
	3541	Machine tools, metal cutting types	0.9	238	0.1
	3542 3545	Machine tools, metal forming types Machine tool accessories	0.4 1.7	60 914	4.9
Process Equipment Subsystems			0.3	212	6.5
	3492 3535	Fluid power valves and hose fittings Conveyors and conveying equipment	0.2 0.4	60 152	0.0 10.9
Process Equipment Components			0.9	1,400	4.3
	3053	Gaskets, packing, and sealing devices	0.1	54	8.5
	3568	Power transmission equipment, n.e.c.	0.0	10	0.0
	3593 3625	Fluid power cylinders and actuators Relays and industrial controls	0.8 1.8	195 1,141	12.1 4.1
Process Equipment			2.9	2,923	-1.1
	3593	Hoists, cranes, and monorails	0.0	0	-100.0
	3547	Rolling mill machinery	16.4	539	-3.6
	3555	Printing trades machinery	0.4	86	2.3
	3563	Air and gas compressors	7.5	1,760	-1.0
	3565 3567	Packaging machinery Industrial furnaces and ovens	0.8 2.0	223 315	15.7 -3.5
Production Machinery			1.0	288	-0.6
	3543 3548	Industrial patterns Welding apparatus	0.9 1.0	70 218	-6.6 2.5
Other Machinery			1.1	845	-0.9
	3564 3589	Blowers and fans Service industry machinery, n.e.c.	0.8 1.2	235 610	-0.5 -1.0
Metalwork	3443	Fabricated plate work (boiler shops)	1.7	1,391	-1.6
Transportation Equipment	3537	Industrial trucks and tractors	0.5	143	8.3
Materials Handling	3596	Scales and balances, exc. laboratory	0.0	0	
Parts	3562	Ball and roller bearings	0.0	0	-100.0
Related Machinery	3556	Food products machinery	0.3	60	-1.7
Specialized Inputs	3291	Abrasive products	1.3	288	5.7
Related Equipment			8.3	15,617	-1.7
	3312	Blast furnaces and steel mills	11.1	15,487	-1.6
	3554	Paper industries machinery	0.0	0	-100.0
	3566 3594	Speed changers, drives, and gears Fluid power pumps and motors	0.8 0.1	120 10	-9.2 0.0
Consumer Equipment			0.0	0	
	3633 3635	Household laundry equipment Household vacuum cleaners	0.0 0.0	0 0	
Metal Processing			2.5	3,474	9.0
	3393	Metal heat treating	1.1	260	7.1
	3569	General industrial machinery, n.e.c.	3.0	1,535	13.7
	3822 3823	Environmental controls Instruments for process measurement	1.8 2.8	385 1,294	-8.1 25.9
Vehicles and Heavy Stamping			0.8	4,449	-2.2
	3465	Automotive stampings	0.6	750	-9.0
	3544	Special dies, tool, jigs and fixtures	2.0	2,531	0.2
	3549	Metalworking machinery, n.e.c.	2.1	385	-1.3
	3711 3824	Motor vehicles and car bodies Fluid meters and counting devices	0.0 4.7	23 760	9.8 0.0
Casting, Forgings and Other Products			1.6	2,870	2.8
	3297	Nonclay refractories	2.8	225	-6.4
	3313	Electrometallurgical products	2.0	82	26.3
	3363	Aluminum die-castings	0.8	235	-6.6
	3462 3469	Iron and steel forgings Metal stampings, n.e.c	1.6 1.8	489 1,839	-1.3 9.3
Construction Machinery	3531	Construction machinery	0.4	379	20.6

As of 2001, the largest regional employers in the cluster are USX, and Allegheny Technologies (primarily in specialty steels and aerospace). However, other firms with production technology workers include PPG Industries (primarily transportation and construction), Westinghouse, Alcoa, and H.J. Heinz, aggregately employing more than 19,000 (including other cluster workers) in the region. New, smaller firms in the region include the PartsHub, Innovex Services, and several Robotics firms, which are linked to information technology and biotechnology, such as CASurgica, PHT, and Interscope Tech.

CLUSTER INNOVATIVE CAPACITY

Specialized research centers. In 1965, Pittsburgh private sector research, mostly manufacturing-related businesses, employed more than 14,500 scientists. Three major closings helped to reduce that number to less than 8,000 by 1975, and that level is still current.¹⁰⁵ The largest research downsizing was U.S. Steel's closing of its research facilities in the 1970s, eliminating 5,000 jobs. In addition, Chevron's buy-out of Gulf Oil and its subsequent headquarters move in the early 1980s, combined with Westinghouse eliminating more than 3,000 research jobs throughout the 1980s and 1990s, compounded the problem. However, since the mid 1980s, several research organizations have emerged that focus on the robotics sector. These have been a function of the work generated by Carnegie Mellon University, but companies in the industry, such as Redbank, also perform robotics research.

Carnegie Mellon University supports production technology with several research institutes.¹⁰⁶ The Center for Integrated Manufacturing Decision Systems is composed of a number of labs, including the Rapid Manufacturing Lab, the Visualization and Intelligent Interfaces Group, the Intelligent Coordination and Logistics Laboratory, the Intelligent Sensor, Measurement and Control Lab, and the Case Based Reasoning and Related Artificial Intelligence Areas Lab. The Center for Iron and Steelmaking Research conducts basic and long-term research concerning iron and steel production, including new ironmaking technologies, steel and special alloy refining, analysis and optimization of continuous casting, and new casting processes. Finally, there is the Green Design Initiative, which seeks to form partnerships with companies, government agencies, and foundations to develop and design, management and manufacturing processes that can improve environmental and product quality while enhancing economic development.

Despite the large number of research institutions, their commercial potential appears under-realized. While nearly 80% of Pittsburgh production technology respondents reported ready access to these local research centers, a full 78% state that the level of knowledge transfer was not helpful to their industry; and 54% state these research institutions rarely transferred knowledge versus 21% who claim they frequently transferred knowledge.¹⁰⁷ Seventy-six percent never use research organizations for innovation, and 83% never use them for commercialization.

Specialized educational institutions and talent pool. According to interviewees, one of the reasons that Pittsburgh is home to manufacturing and production firms is the work ethic and skills of the local residents. In addition, Pittsburgh has many technical schools that include computer training institutes, such as ProTech Professional Technical Services, community colleges, and vocational schools such as the Bidwell Training Institute and ITT Technical Institute.¹⁰⁸

However, Pittsburgh production technology executives are concerned about access to skilled workers, as 56% report that the supply of skilled workers was insufficient for growth needs.¹⁰⁹ The range for other regions was 35% to 51%. Moreover, as in other clusters studied, several production technology executives note the lack of managerial talent, specifically in marketing and sales.

Exhibit 89: Major Production Technology Research Institutes in Pittsburgh

Institution	Focus
The Center for Machine Translation	Provides basic/applied research on natural language processing, focuses on machine translation, speech processing, and information retrieval
The Computer-Aided Process Design Consortium	Develops methodologies and computer tools for the process industries
The Center for Integrated Manufacturing Decision Systems	Includes the Rapid Manufacturing Lab, the Visualization and Intelligent Interfaces Group, the Intelligent Coordination and Logistics Laboratory, the Intelligent Sensor, Measurement and Control Lab, and the Case-Based Reasoning and Related Artificial Intelligence Areas Lab
Medical Robotics and Computer Assisted Surgery	Foster the application of robotic technologies within medicine
The Robotics Institute	Basic research and advanced development on vision, manipulation, planning, control and mobility, includes Field Robotics Center, the Imaging Systems Laboratory's, the Learning Robots Laboratory, Manipulation Lab, the Measurement and Control Laboratory, the Microdynamic Systems Laboratory, Vision and Autonomous Systems Center
The Government/University/Industry (GUIDe) Consortium on the Forced Response of Bladed Disks	Develops new methods to improve technology for predicting and controlling blade vibration in rotating machinery
The Center for Iron and Steelmaking Research	Researches for production of iron and steel, including new iron-making technologies, steel and special alloy refining, analysis and optimization of casting processes
The Robotics Engineering Consortium	Entrepreneurial entity — develops products with advanced robotics technologies
The Institute for Complex Engineered Systems (ICES)	Performs multidisciplinary research on complex systems, includes Engineering Design Research Center, or EDRC and the Thermal Management & Electronic Cooling Lab
The Mobile Robots Laboratory	Does long-term basic research in perception, control, and planning for robots
The Shape Deposition Manufacturing Laboratory	Utilizes its research to create multi-material, embedded structures not produced with traditional manufacturing technology

Sophistication of regional demand. According to our survey, local customers are demanding, with 57% of executives reporting that customers spur them to create new products and services. The range for other regions in our study is 46% to 62%. Thirty-nine percent of production technology executives express a desire to obtain more frequent feedback from their customers about product offerings.¹¹⁰ Production technology executives also do not state that regional cluster firms have an advantage in perceiving customer trends (only 18% state it is an advantage).

Related and supporting industries. Pittsburgh production technology executives do not give their specialized suppliers good marks. Forty-three percent state specialized suppliers were mostly not available within the region. The range for other regions was 26% to 42%. Eighteen percent of the respondents report their regional suppliers are of low quality, compared to 11% to 14% in other regions.¹¹¹ About 33% of the respondents consider their specialized suppliers as frequent contributors to their innovation efforts, versus a range of 34% to 45% in the other regions.¹¹²

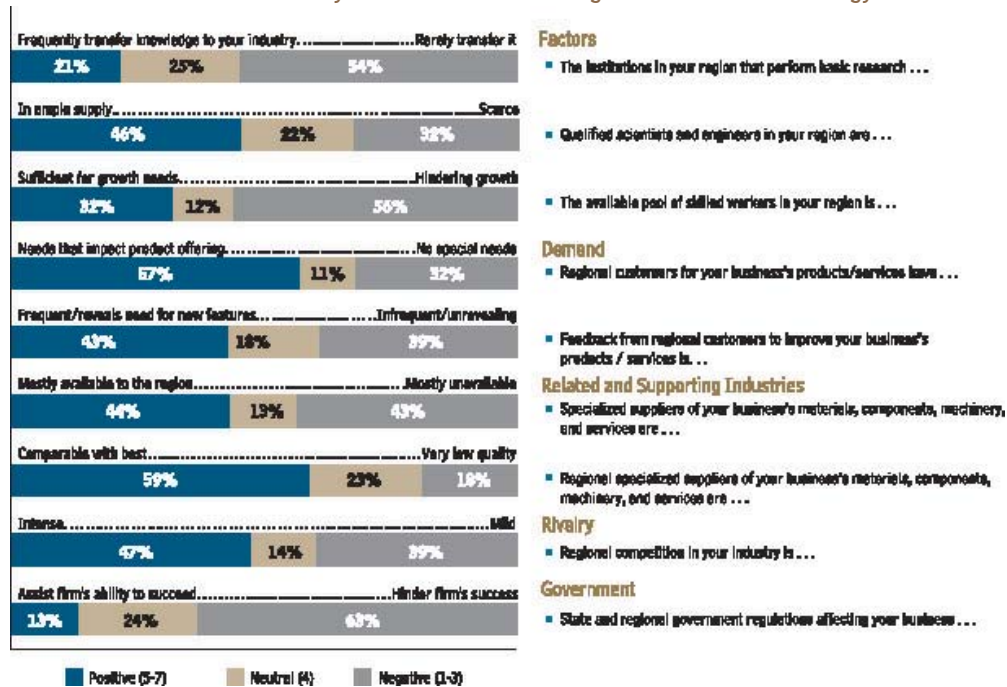
Context for firm strategy and rivalry. The context for firm rivalry and strategy does not foster innovation due to low levels of both competition and collaboration.

Only 47% of survey respondents describe competition in their cluster as intense, which is on the low end of the 43% to 71% range for all regions studied. Forty-three percent state there were many firms competing in the industry, versus a range of 42% to 64% in other regions. Fifty-four percent claim there were average to few firms competing locally (3% are neutral).

Executives in the Pittsburgh cluster have mixed views about the amount of firm-level collaboration in the region. Only 18% state that they share information, and only 17% state that firms share knowledge. These figures are lower than the biotech and information technology clusters in the region. The overall range for the other regions studied was 34% to 44%, and 29% to 50% respectively.

As Exhibit 90 indicates only 21% of local institutions share knowledge and availability of basic and skilled labor is a concern. In addition, local customers do not, on average, provide an insightful advantage and the government receives poor grades for supporting the industry. Although regional steel firms tend to ask the government for tariffs as well as for business enabling activity. Regional suppliers do appear to give local firms an advantage, and half the firms (47%) face intense competition.

Exhibit 90: Select Survey Results from Pittsburgh Production Technology Executives



Source: Clusters of Innovation Initiative Regional Survey™

Government. Government has been an important contributor to the growth of innovative capacity in the cluster, primarily through federal funding of R&D, medical-based robotics research, and state funding of colleges and universities. Private firms such as Redzone have also received federal funding for robotics research. Before leaving office, Governor Ridge and Team Pennsylvania had sessions for prioritization of Pennsylvania business issues and provided grants to manufacturing firms and support and loans through Innovation Works for robotics efforts. At the local level, Pittsburgh has provided tax breaks for several robotics firms. However, interviewees state that there are too many municipalities, which is not cost effective and which cannot collaborate on common issues.

Production technology executives in our survey state that the most important priorities for the government in the next five years are providing world-class primary and secondary education (95%), providing education and training programs (92%), providing strong intellectual property laws (82%), and improving the transportation infrastructure (80%).

Institutions for collaboration. Pittsburgh production technology cluster executives have historically had a reputation for civic collaboration. They provided the region with two self-proclaimed renaissances of cooperation, where regional CEOs and the Allegheny Conference focused on city wide clean-up and cultural improvements. Today, organizations such as the Advanced Manufacturing Network (through the Pittsburgh Technology Council) focus on manufacturing and related workforce issues.

However, survey results indicate that the production technology focused institutions for collaboration are not especially effective. Only 27% of production technology executives say their cluster associations were effective, compared to a range of 39% to 60% in other regions. Although 79% of the production technology executives state that research providing organizations are readily available in the region, only 21% say that they frequently transfer knowledge, versus 42% for all of the region’s respondents. These percents are all well below other regions.

When asked about specific organizations (See Exhibit 91), only national associations had more than one-third (47%) of the respondents citing that they are helpful. Local organizations do not perform so well as approximately one-quarter of the production technology respondents state that university networks, tech transfer offices, economic development organizations and regional councils are helpful. These are very low compared to other regions.

Exhibit 91: Select Survey Production Technology Results on Pittsburgh’s Institutions for Collaboration

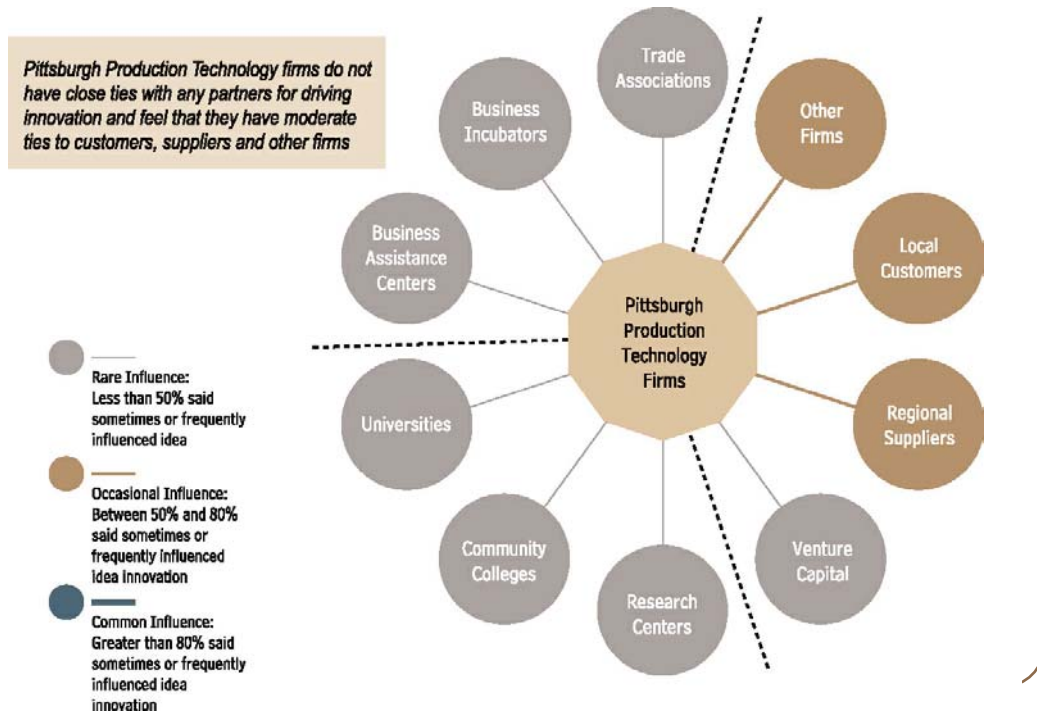
	Percent Reporting Helpful		Percent Reporting Unhelpful	
	Established	Entrepreneurial	Established	Entrepreneurial
National Trade Associations	46%	47%	54%	53%
Economic Development Organizations	25%	24%	75%	76%
University-based Networking Organizations	26%	29%	74%	71%
Regional Industry or Cluster Councils	29%	24%	71%	76%
University Technology Transfer Offices	19%	22%	81%	78%

Source: Clusters of Innovation Initiative Regional Survey™

We also asked survey respondents how frequently they interacted with other members of the cluster at the idea generation, product development, and commercialization stages of the innovation process (see Exhibit 92). In Pittsburgh, production technology firms do not have close ties with any group within the cluster for idea innovation. There are only moderate ties with customers, other firms, and regional suppliers when generating new ideas, and only one in four say that they frequently use outside partners in their idea development or commercialization processes.

In addition, regional customers have the highest satisfaction levels for their impact on the innovation process among production technology executives (51%), followed by other firms (48%), and regional suppliers (46%). The next highest satisfaction score is universities, at just under one-third of respondents.

Exhibit 92: Frequency of Interaction among Production Technology Cluster Members on Commercialization



Source: Clusters of Innovation Initiative Regional Survey™

CONCLUSION

Despite losing jobs during the past three decades, the production technology cluster remains a major employer in Pittsburgh. Several subclusters have experienced employment growth recently, but the overall contraction continues, particularly in basic steel. Although wages have grown and stabilized against the national average, regional innovation is decreasing. Nevertheless, the region has great potential for cross-fertilizing ideas with cluster members and newer clusters. This includes leveraging universities, associations and research centers, customers, suppliers, and competitors. The genesis of this can be found with collaboration of the universities and private-sector firms in robotics, information technology, and biotechnology.

The important lesson from the production technology cluster in Pittsburgh is that firms, industries, and clusters must continually focus on innovating to provide superior goods and services to customers. Complacency and risk aversion to new technology almost eliminated the steel industry in Pittsburgh. However, firms have caught up technologically, migrated to specialty mills and focused on more profitable niche markets. Within the cluster, two positive trends are emerging. First, older firms are upgrading their technology to parity with foreign competition; Wheeling-Pittsburgh Steel Corporation, for example, is modernizing its information technology and telecommunications infrastructure. However, general improvements appear to be focused on assimilating new technology as opposed to true innovation, as evidenced by patent trends, and it is the true innovation that will most likely create more wealth. Second, robotics is not only gaining momentum, but also assisting with cross-fertilizing innovation into other regional clusters.

SUSTAINING COMPETITIVE ADVANTAGE: LESSONS, CHALLENGES, AND OPPORTUNITIES

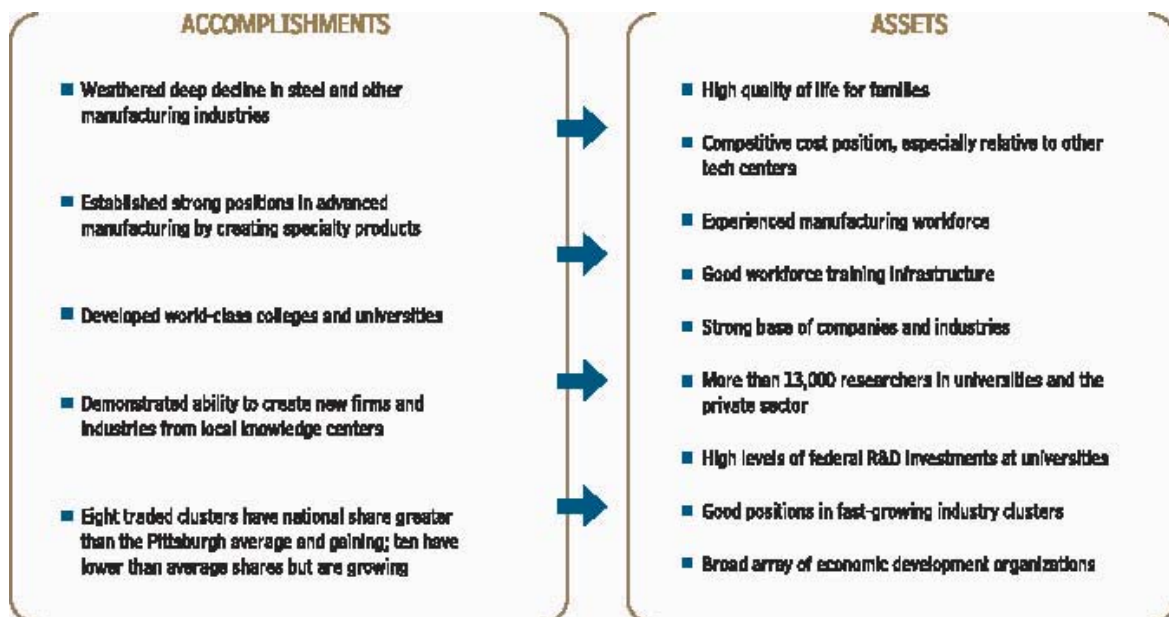
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Accomplishments and Assets

Over the past 15 years, Pittsburgh has been on a gradual recovery course from the demise of basic steel production, the regional downsizing of local firms such as General Electric and Westinghouse, and an exodus of firms such as Gulf Oil. Recovery has occurred due to growth in a diversity of service and new-technology industries, and the reinvention of the metal manufacturing and production technology clusters.

In many ways, the most notable accomplishment in Pittsburgh is the significant upgrading of the region's colleges and universities. The education and knowledge creation cluster is relatively strong and growing. The University of Pittsburgh and Carnegie Mellon University have become well-respected engineering and bioscience research institutions. Their knowledge centers have demonstrated the ability to spin out leading technology companies such as Galt Technologies, Lycos, and FORE Systems.

Exhibit 93: Accomplishments and Assets



These accomplishments have left Pittsburgh with numerous assets with which to develop its economy. The region retains a skilled manufacturing workforce and offers a competitive cost position for companies, due to a lower than average cost of living in the region. Interviewees boast of theater, the Philharmonic, museums, and the nearby mountains, with outside recreational activities.

The 30 local universities and colleges, and the 80 technical schools, provide a strong workforce training infrastructure. The schools are among the best in the country for engineering, computer studies, and related medical services (e.g., medical devices, and analytical instruments). The universities and local research organizations are approaching one-half billion in research funding, contain hundreds of specialized research institutes, employ over 13,000 researchers, and are developing new programs such as the Robotics Institute. The region has also enjoyed some success in attracting research firms such as RAND, Seagate, and SONY.

Pittsburgh has taken advantage of support from the state of Pennsylvania for downtown development, including a new conference center, sports arenas, and industrial parks. State support and initiatives include Technology 21, an eight-pronged technology development plan; early stage VC funding; and Innovation Works, which has issued almost \$6 million in loans, provided firms with angel investor connections, and instituted mentoring programs. Pittsburgh has attracted over a half-billion in venture capital funding since 1995, mostly for the information technology cluster, and has almost \$2 billion in available funds in 2001.¹¹⁴ In addition, the region's tech transfer offices have assisted more than 70 firms to spin out, usually from within the university system.

Lessons

Pittsburgh's accomplishments, and the process by which the region has encouraged the development of the economy, offer numerous lessons for other regions.

Innovation drives prosperity. Pittsburgh's industrial core in steel and aluminum was driven by fundamental innovations in technology. Steel fell behind due to the ability of international competition to deploy new innovations to surpass Pittsburgh's productivity. For production technology, the early mills were initially galvanized by Andrew Carnegie's use of blast furnace and Bessemer Converter technology and later innovations by Frederick Taylor at Bethlehem Steel, which Pittsburgh firms adapted. For the knowledge-intensive clusters, continual innovation at the universities and the University of Pittsburgh's collaboration with the local hospital network have provided a basis for generating talent and for firms to generate new technology.

- **Local competition drives innovation.** Led by Andrew Carnegie, who continually pushed for innovations, Pittsburgh was a hotbed of mills and innovation before the turn of the century. However, as U.S. Steel consolidated the region's mills, local competition was reduced, innovation waned and the firm continually lost market share to firms such as Bethlehem Steel and eventually to foreign firms. Pittsburgh firms could find themselves in a similar situation, as competition is not robust locally and innovation levels are being surpassed at the national level.
- **Diversification across several clusters helps to buffer a regional economy.** The Pittsburgh economy in the 20th century was dominated by steel production. It grew out of the natural endowments of the region (e.g., abundant coal and easy river transportation), became strong through the work of innovative entrepreneurs, and later enjoyed success due to the worldwide dominance of U.S. industry. After World War II, however, both foreign and domestic

competitors began to rival Pittsburgh steel companies, and by the early 1980s, local firms began a massive downsizing. Roughly 150,000 workers lost their jobs. These losses pushed the region into a severe recession, and although growth returned, the region has never fully recovered. Although successful regions have strength in only a handful of clusters, some diversification is important to avoid the sort of crisis Pittsburgh experienced.

Exhibit 94: Pittsburgh's Lessons

- Innovation drives prosperity
- Local competition drives innovation
- Diversification across several clusters helps to buffer a regional economy
- Cluster development is a long-term process
- R&D investment is critical, but only a part of innovation

- **Cluster development is a long-term process.** The basic assets for the information technology and biotech/pharma clusters were developing in Pittsburgh by the 1970s and 1980s, but the clusters did not emerge until the 1990s – and elements of the cluster are still underdeveloped. Reasons provided for the lag are that the metro area lacked people with management experience and risk capital. But the reasons should also include a lack of collaboration and a lack of local demand and supporting industries. Local leaders, the universities, and the Pittsburgh Technology Council appear positioned to create the basis to move the cluster to the next level, using a long-term strategy to focus on these issues. Our interviews and surveys indicate that local leaders believe that there is a strong advantage when working in industries that have regional critical mass. They know that firms can share information and learn from both suppliers and competitors. They also understand that competitive advantage derives from having access to superior research, as they know that risk capital chases good ideas. At some point, the addition of sophisticated local demand and numerous suppliers and organizations that help firms innovate will become key advantages in this region. Because it takes time to build these assets, clusters in Pittsburgh should focus on doing so now.
- **R&D investment is critical but only a part of innovation.** Pittsburgh is strong in university research and development, receiving more than twice the national average for federal R&D spending per worker. However, it is lagging in innovation, and therefore lagging in the ability to create products, relative to the nation. This is due in part to the fact that private sector research employment dropped from 14,500 in the mid 1960s to 8,000 in the mid 1990s. It is also due to relatively inefficient knowledge commercialization, evidenced by the region's higher than average patents per worker, but the lower than average establishment growth, fast growth firms, VC investments per worker, and IPOs per worker.

Challenges

Despite its accomplishments, Pittsburgh faces several challenges, which it needs to meet in order to achieve the next level of regional success. Examples of these challenges include the rationalization and utilization of collaborative organizations and improvement of the start-up environment, which includes a focus on the issue of outmigration of younger talent.

Difficulties in workforce retention and recruitment. After the downturn in steel, many people left Pittsburgh, and the region soon felt the effects of the decline in population. The leaders and workers of tomorrow, those aged 18-44, continue to leave Pittsburgh. Carnegie Mellon, for example, estimates that only 24% of undergraduates stayed in the region in 1999 (although this is an improvement from 18% in 1990). In addition to concerns for retaining younger talent in all fields, specific deficits that were noted in the interviews included general managerial and marketing skills. Despite having strong business programs in the region, many MBAs leave the area upon graduation. This might be improving slightly as a more recent report shows that among all universities, over 50% of graduates stay in the region.

Low levels of innovation. Particularly in an advanced economy, high and rising levels of prosperity depend upon high and rising levels of productivity. Innovation, in turn, is necessary to boost productivity over the long run. Although patents per worker in Pittsburgh are above the national average, the region lags in virtually every other measure of innovation including patent growth, new establishment formation,

Exhibit 95: Pittsburgh's Challenges

- **Difficulties in workforce retention and recruitment**
 - Boost regional retention rate of college graduates
 - Concerted strategy to recruit outside workers
- **Low levels of innovation**
- **Challenging environment for start-up and growth companies**
 - Limited local venture capital in many sectors
 - Limited opportunities for networking
 - Limited availability of specialized support for start-ups and growth firms
- **Underdeveloped clusters**
 - Relatively weak local supplier base in studied clusters
 - Relatively weak linkages with local customers in studied clusters
- **Weak collaboration and coordination**
 - Fragmented local government
 - Under-leveraged institutions for collaboration
 - Need for greater collaboration among groups throughout the community
 - Need for coordinated leadership
 - Need for shared vision
- **Aging physical infrastructure and logistical concerns could be constraint on growth**

VC funding per worker, number of fast-growth firms, and IPOs. The region has a good standard of living at the moment, but these relatively poor innovation metrics indicate it will be difficult to maintain current levels of prosperity in the future.

Challenging environment for start-up and growth companies. There is a developing network for start-up firms in Pittsburgh. The state has implemented programs that assist in removing several hurdles with financial and mentor support. In addition, there are almost 30 business incubators in the region, many of which developed in the past decade. However, based on surveys and interviews, start-up companies face many challenges. These include the need to have access to knowledge centers, lack of management and marketing expertise, limited local venture capital in many sectors, few effective networking opportunities, and lack of specialized support companies (e.g., accountants, lawyers, consultants).

Underdeveloped clusters – including firms, weak local supplier and customer networks. It is clear from both patent data and the lack of strength with innovative networks that the innovation environment is relatively weak compared to other major markets. Supporting this is data from the survey. Sixty-five percent of Pittsburgh respondents state that cluster firms infrequently share knowledge, versus a range of 35% to 49% in other regions. Seventy-two percent of Pittsburgh respondents state that firm-organization relationships do little to assist with R&D efforts, versus a range of 42% to 55% in other regions. Within studied clusters, there appears to be a dearth of supporting firms, managerial talent, and a critical mass of upstream and downstream firms. For instance, more than 40% of Pittsburgh respondents state that specialized suppliers of business’s materials, machinery, and services are mostly not available versus a range of 25% to 36% in other regions. Forty-nine percent of Pittsburgh respondents state that regional specialized suppliers infrequently assist their firms with new product and process development, versus 31% to 38% in other regions.

Pittsburgh leaders have had success in attracting research firms such as RAND, SONY and Seagate, by creating innovative environments, with initiatives such as the Tissue Engineering Initiative and the Robotics Institute. But creating improvements in the overall innovation environment is tied to developing the connectivity levels both within and across clusters, with better support from customer learning initiatives and from other cluster members’ involvement.

Weak collaboration and coordination. Local government is divided into roughly 130 municipalities. While receiving high grades for undertaking large projects, such as the new sports centers, the upcoming convention hall, and the downtown mall projects, local government is criticized by our interviewees for not creating the right environment for attracting jobs and young people. It also has poor marks for collaborating with leaders in developing industries.

Similarly, local institutions for collaboration have trouble fostering collaboration. According to our Clusters of Innovation Initiative Regional Survey™, only 26% of Pittsburgh’s executives surveyed state that these organizations are effective, versus a range of 39% to 60% in other regions. Only 12% of Pittsburgh executives reported that relationships between organizations and firms in clusters are important for R&D efforts. The range for other regions fell between 25% and 44%. Ironically, of all studied regions, Pittsburgh had the largest number of institutions for collaboration, indicating that these organizations are under-leveraged.

One reason for these low levels of collaboration is the local attitudes and culture. Numerous interviewees describe the region as “parochial,” “cliquish,” and even “balkanized.” Innovation, however, flourishes where people having different experiences and areas of expertise come together and commu-

nicate their ideas. Breaking down barriers between groups to enable a freer flow of information and ideas will be important to Pittsburgh's economic future.

Despite an abundance of organizations that focus on development issues, there appears to be a lack of a unified vision on the region's development strategy. Not since the Pittsburgh renaissance period in the 1950s and 1960s, when organizations, business leaders, and the city government collaborated to revitalize the downtown, has the region experienced a shared vision. In order to build an effective agenda, private sector leadership will be required to develop a collaborative group from the private and public sector as well as including supporting institutions. There is a need to move beyond piecemeal initiatives to prioritize and focus on the critical challenges and opportunities. This will require action orientation with measured results, timelines, and accountabilities. In addition this will require the investment strategy to be aligned with those prioritized needs. Ultimately, Pittsburgh appears to face the additional challenge of low levels of collaborative attitudes for leaders to clearly hear issues from key clusters.

Aging physical infrastructure. Although leaders in Pittsburgh had the foresight to build a first-class airport, numerous physical infrastructure issues remain. Traffic in and around the metro area is stated as a problem, with commute times comparable to Boston and longer than San Jose. In addition, several interviewees state that the entire sewage system is aging and needs to be replaced. Attention to these mundane but important issues will be necessary for the region to succeed.

New Directions

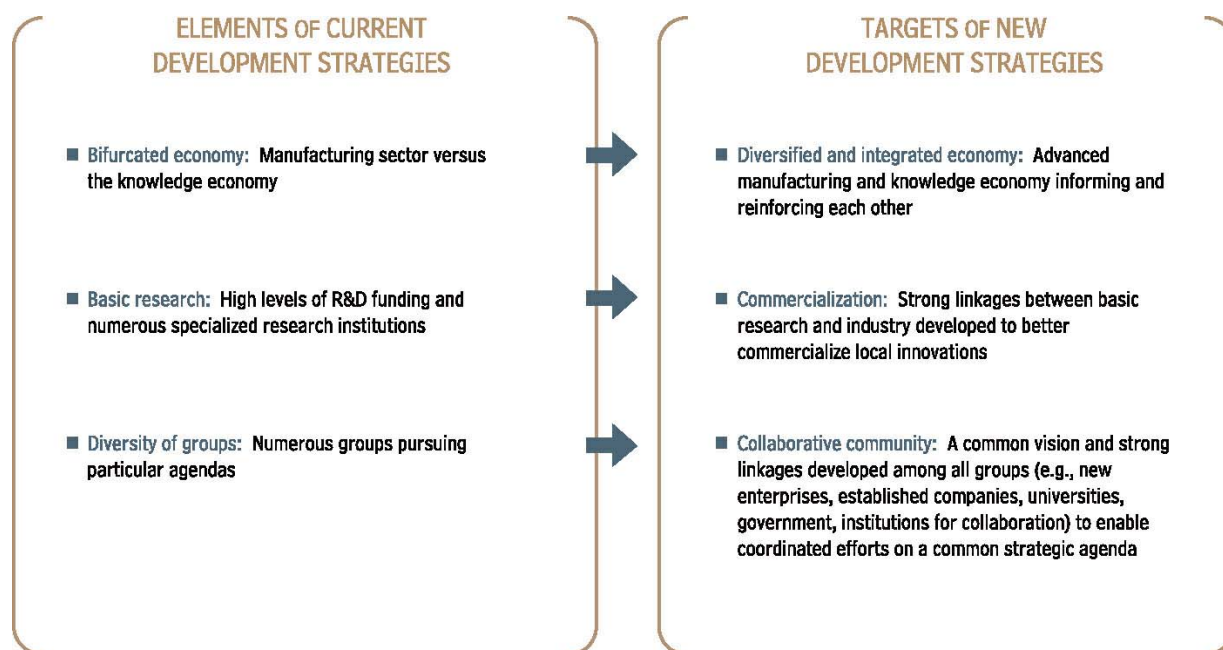
Pittsburgh's historic accomplishments made it a highly innovative and competitive region. Competition, however, is dynamic, and to remain competitive, Pittsburgh must be dynamic as well. Our analysis identifies several themes by which Pittsburgh can transition from a slowly growing economy to a diversified, mature, and strongly performing economy.

From a bifurcated economy to a diversified and integrated economy. Pittsburgh was once the preeminent steel town in the world, and it remains a center of manufacturing in America. More recently, the high-profile successes have been in new technology industries such as biotech/pharmaceuticals and information technology. Our interviews uncover a strong sense of rivalry between these "old" and "new" economies. Competition is certainly vital for any economy, but not at the expense of collaborative opportunities. Pittsburgh should strive to become a model 21st century economy, having advanced manufacturing and innovative service and knowledge-based industries, which can assist in informing the two cluster models to drive innovation. The universities, the Pittsburgh Technology Council, and the Regional Alliance can act to support methods for attracting new innovative firms and for creating the forums to get the old and new clusters to educate each other on their issues to develop the basis for innovation.

From basic research to commercialization. Some of Pittsburgh's most valuable assets are its research universities and institutes. Leaders at the University of Pittsburgh and Carnegie Mellon have built world-renown centers of research in transplantation, bioscience, computer science, and engineering. The region has hundreds of specialized research institutes and produces thousands of trained workers. In addition, many of the researchers at the universities have branched out and started their own firms, using the support of the universities to develop their ideas. These types of assets can be a driving force in economic growth, as is also demonstrated by regions such as San Diego and Raleigh-Durham.

To capitalize on these assets, however, more basic research must find its way to commercial applications. Interviews and surveys tell a similar story of underutilized research in local knowledge centers. This is a much larger issue than simply improving the efficiency of a technology transfer office. Indeed, to leave this large task to a single office is to guarantee that a bottleneck will develop. The task requires that universities and businesses develop multiple points of formal and informal contacts through which knowledge, expertise, and trained talent can flow.

Exhibit 96: New Directions for Pittsburgh



From a diversity of groups to a collaborative community. To remain competitive, companies must innovate and constantly change in ways that improve their value proposition. Often the best innovations come from outsiders precisely because they look at problems differently. Successful regions tend to have formal collaborative institutions and informal networks that foster interdisciplinary contacts and spur innovation.

Yet, the regional survey of Pittsburgh executives indicates that networking across various groups (e.g., start-ups, established companies, academia, municipalities, “new economy,” “old economy,” etc.) is minimal. Leaders in Pittsburgh are aware of this issue, and of the regions we studied, Pittsburgh has the highest number of formal organizations whose mission is to foster networking. Given the many opportunities, it seems there is an attitudinal disinclination to network, and indeed, interviewees in Pittsburgh overwhelmingly report that this is true. These attitudes can change through leadership from influential individuals and effort by the communities involved. When they do change, the cross-cluster potential for synergies in a diversified economy such as Pittsburgh’s will be considerable.

Opportunities

Pittsburgh has a variety of opportunities that are under-realized, which include unlocking university potential, organizing across clusters, leveraging state and county government's business focus, and focusing on Pittsburgh's potential healthcare leadership.

Build global leadership in both advanced manufacturing and new technologies. Despite severe manufacturing declines, Pittsburgh retains strong positions in several manufacturing areas: glass, clay, and vitreous products; heavy equipment; analytic, medical, and process instruments; and metal processing and products. It also has a relatively strong position in transportation and logistics. Finally, with its universities and research institutions, Pittsburgh has the assets to excel in clusters such as communications equipment, biotech/pharmaceuticals, and information technology. In short, Pittsburgh has an opportunity to become a model economy of the 21st century, with strength in both advanced manufacturing and new technologies.

Exhibit 97: Pittsburgh's Opportunities

- **Build global leadership position in both advanced manufacturing and new technologies**
- **Better unlock commercial potential in universities**
 - Improve knowledge commercialization (e.g., UCSD CONNECT or Digital Greenhouse model)
 - Create facilities to foster networking (e.g., Centennial Campus model)
- **Enhance Pittsburgh's position as a medical center**
- **Attract non-university research institutions**
 - Increase the number of local researchers
 - Build bridges between basic university research and industry
- **Enhance the agenda and action orientation of cluster-specific organizations**
- **Organize and pursue growth opportunities at the intersection of clusters**
- **Better leverage the state government to assist in prioritized strengthening of the business environment**
- **Market the region's opportunities and strengths both inside and outside the region**

Better unlock the commercial potential in universities. Universities are a driving force of economic development and innovation in the successful regions we have studied. They can both attract and help keep talent in a region, they are a major source of innovation, and they can facilitate cluster collaboration and help institutionalize cluster linkages through university-based institutions (e.g., Carnegie Mellon's Donald H. Jones Center for Entrepreneurship). Local universities and colleges in Pittsburgh do perform these roles, but they remain under-leveraged assets. The level and quality of university research and training are very high in Pittsburgh, but the commercial impact appears comparatively low (e.g., new

establishment formation, VC spending). Survey and interview results support this conclusion. Local universities have the potential to be engines of economic development in Pittsburgh. What is more, few other organizations in the region have that potential. Better unlocking of the commercially applicable knowledge and assets in the universities is a high priority for the region.

Enhance Pittsburgh's position as a medical center. Sophisticated local demand that anticipates the needs of a larger market gives a local cluster insight into market trends and an advantage for innovation. The population of Pittsburgh is much older than the national average, and this market will forecast the demands of the U.S. population as the baby-boomer generation ages. Few other regions can match this particular advantage. The University of Pittsburgh and its affiliated medical center system currently employ more than 25,000 people, with more than 3,000 physicians, and serve the second oldest market in the country. They receive NIH funding for gene therapy, minimally invasive surgery, and the pioneering transplantation program for artificial heart, lungs, kidneys, pancreas, liver, and blood substitutes.¹¹⁵ Although the region is focusing on biotech, with strategies that include developing related venture capital, and leveraging Innovation Works to focus more on biotech funding and mentorship, healthcare represents a key opportunity for the region.

Attract non-university research institutions. With its numerous colleges and universities, expertise in many fields of study, close proximity to Washington, D.C. and New York, and reasonable cost of living, Pittsburgh should be able to attract non-profit and for-profit research centers. Such research centers are not only valuable in their own right as centers of innovation and training, but also help satisfy two of Pittsburgh's critical needs. First, they can help bridge the gap between basic research in the universities and commercial needs of industry. Second, they can help reverse the shrinking population in younger age categories. Local research institutes will offer jobs to the many graduates of Pittsburgh colleges and universities, and they will attract young scientists, engineers, and researchers from around the country and even the world.

Enhance the agenda and action orientation of cluster-specific organizations. One of Pittsburgh's assets is the large number of institutions for collaboration. In addition, local leaders have done a good job of creating overarching institutions and coordinating efforts of several groups, such as the Pittsburgh Technology Council and Pittsburgh Regional Alliance. However, two types of important collaborative institutions are still underdeveloped in the region: institutions to connect knowledge centers with industry (discussed above) and cluster-specific institutions.

Cluster-specific institutions focus on the needs of a given cluster, ensure that firms in that cluster are aware of, and have access to, all useful assets in a region, and in general focus on growing their cluster. Having these institutions is particularly important in Pittsburgh for two reasons. First, although overall traded employment is close to national averages, clusters in Pittsburgh remain relatively weak. Only seven out of 41 clusters in the MSA are relatively large and growing. Because new clusters often grow out of the intersection of existing clusters, and because many clusters buffer a region from a downturn in a large cluster, it is important to have strength across many clusters. Second, executives in the clusters we surveyed report a lack of networking and information flow among firms, suppliers, customers, and input providers in the region. This is precisely what cluster-specific institutions would seek to improve. The Pittsburgh Technology Council, for example, is well positioned for information technology, biotechnology and production technology, but can be leveraged with greater support from institutions, the universities and government.

Organize and pursue growth opportunities at the intersection of clusters. Pittsburgh has a number of relative strengths that offer fertile ground for interdisciplinary collaboration. For example, engineering at Carnegie Mellon and biosciences at the University of Pittsburgh provide the bases for developing tissue engineering. To capture these potential areas of growth, the region needs to build institutions for collaboration that link diverse clusters.

Better leverage the state government to assist in prioritized strengthening of the business environment. The state government has effectively supported the Pittsburgh economy over the years. State and regional levels have assisted with factor development with items such as building a world-class airport and improving the transportation and communication infrastructure. They are now beginning to work with firms to understand information-based and other needs, and the state in particular has created successful programs with Innovation Works, a \$150 million “Early Stage Partner Fund,” Enterprise Advocates mentoring program, Technology 21, and a marketing program that focuses on technology development in Pennsylvania.

As the state and county are actively supporting business needs, there is an opportunity to engage in a structured cluster development program. For instance, they could participate in developing region-wide training programs, similar to Greenville, South Carolina, whose training programs help attract foreign firms and investment. The state and county in Southwestern Pennsylvania nurture related and supporting industries by sponsoring forums and providing free trade zones. Within the context for firm strategy and rivalry, they have succeeded in assisting to bring firms into the area, such as Federal Express or Intel, but they can focus on opportunities to support regional entrepreneurs as well. With more coordination, they could improve efforts to attract suppliers from other locations. For example, they can further expand their successful services for start-ups or they can work with regional leaders to focus on entrepreneurial needs, for both business and leisure activities. Finally, in terms of customer demand, they have not consistently acted as demanding consumers nor provided ratings for cluster products and services.

Market the region’s opportunities and strengths both inside and outside the region. One of Pittsburgh’s greatest challenges is workforce retention. Many locals leave the area, and relatively few outsiders relocate to Pittsburgh. Yet the region has much to offer as evidenced by the research strength of local universities, the initial successes of numerous firms that spun-out of local universities, and the high quality of life. Leaders should market these advantages to young workers both inside and outside of the region.

Organizing for Action

Pittsburgh has the assets in place to be a dynamic and diversified economy. Although it must meet several challenges and seize numerous opportunities to succeed, its development agenda is clear. This agenda is supported by more than 25 reports that have been commissioned and compiled since the 1994 report, “The Greater Pittsburgh Region: Working Together to Compete Globally.” The themes from these reports echo many of those outlined in this study (see Exhibit 98).

Although Pittsburgh has made progress on many of these issues, our quantitative data, interviews and survey results indicate that the region lags competitor areas, specifically when it pertains to innovation growth and cluster development. Compared to what Pittsburgh needs to do to compete in a global economy, progress appears to be impeded. Numerous interviews confirm that Pittsburgh has some trouble implementing a regional development agenda.

Exhibit 98: Recent Report Titles in the Pittsburgh Region

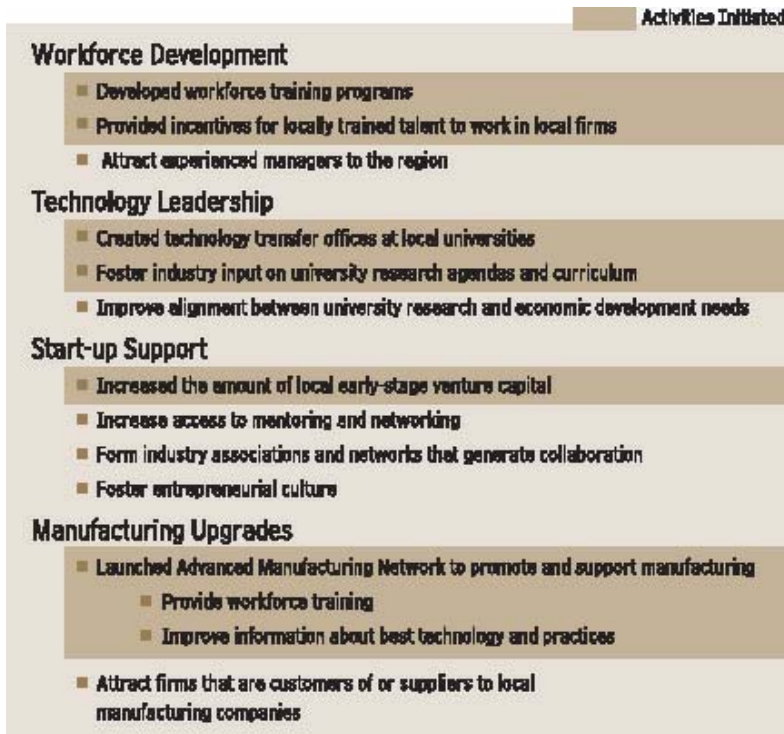
STRATEGY DEVELOPMENT AND ANALYSIS REPORTS	ECONOMIC UPDATES AND PROGRESS REPORTS
Putting the Customer First: A Strategy for Improving Pennsylvania's Economic Development Service Delivery System; Corporation for Enterprise Development (Washington D.C.), August 1993	Progress Metrics for the Entrepreneurial Economy; CED, November 2000
Business Development: A Strategy and Action Plan to Accelerate Economic Growth in Southwestern Pennsylvania; McKinsey & Company, November 1997	The 1998 Entrepreneurial Vitality Scorecard: The Pittsburgh Metropolitan Area; CED (Regional Rankings in PA)
Growing the Economy of the Future; Innovation Works, Inc., November 1998	Technology: The State of The Industry Report; Pittsburgh Technology Council, August 1998
Engine of Infrastructure? The University Role in Economic Development — Richard Florida, 1999	The Regional Economic Revitalization Index 1998; CED for the Working Together Consortium, May 1998; The Regional Economic Revitalization Index 1999; The Working Together Consortium
Competing in the Age of Talent: Environment, Amenities and the New Economy, Richard Florida, January 2000	1. Migration and Regional Growth; 2. Technology Cluster Establishments in the Pittsburgh Region; CED, 2000
An Action Plan for Improving the Entrepreneurial Vitality and Technology Economy of the Pittsburgh Region; Technology Commercialization and Entrepreneurship Task Force for the Working Together Consortium, January 1998	The Pennsylvania Regional Challenges Report Card; CED and the Corporation for Enterprise Development; CED website, 2000
Manual for Establishing Cluster Initiatives: Ohio Growth Project; McKinsey & Company, June 2000	Key Characteristics of the Southwest Pennsylvania Workforce and Labor Market; Pittsburgh Regional Alliance; December 1999
Transition Workforce Development; Allegheny County Commissioner, 2001	The State of the Region Report: Economic, Demographic and Social Conditions in Southwestern PA, Ralph Bangs, Ph.D., September 1999
Southwestern Pennsylvania Industry Cluster Analysis — The Emerging Life Sciences Cluster for The Pittsburgh Technology Council; CED; Collaborative Economics and Tripp Umbeck Associates — In process	University of Pittsburgh — Pittsburgh Economic Quarterly — Out Migration Study, June 2000
Opportunities for Growing the Information Technology Cluster —Center for Economic Development at Carnegie Mellon University, January 1999	The Regional Economic Revitalization Index 2000
Entrepreneurial Pittsburgh: Uncovering the New Economy — The John Heinz III School of Public Policy; 13 authors; Don Smith advisor, May 2000	The Working Together Consortium: Final Progress Report 1994–2000, 2000
Working Together to Connect Workers to Jobs of the Future; Working Together Consortium, 2000	
Bioventure Analysis: Patel Memorial Initiative for the Pittsburgh Tech Council; In Progress — as development for new Biotech development initiative, Center for Economic Development (CED)	

Why Strategies Fail

For an economic development strategy to succeed, leaders in a region need to have a clear agenda, and they must also have the capabilities to achieve success. However, several issues can hinder or stall regional progress. One is that companies and organizations pursuing their own individual interests may act contrary to the needs of a regional economy. This lack of shared vision and information sharing can lead to lower regional innovation levels, which, as shown in the past, will have a negative impact on regional job and life quality. Second, in addition to not having the same agendas, the multitude of organizations that need to contribute to regional development may not collaborate well. This lack of collaboration can create parallel but less effective efforts. Third, it is difficult for one individual or organization to lead a regional economic development agenda. Organizing for action entails overcoming these three obstacles and creating the capacity for regions to implement development strategies. Finally, the urgency for change may not be great.

A template for successful regional economies focus on the contributions of many organizations: companies generate innovations, jobs and wages; universities produce research and trained graduates; govern-

Exhibit 99: Themes from a Decade of Study of the Pittsburgh Economy



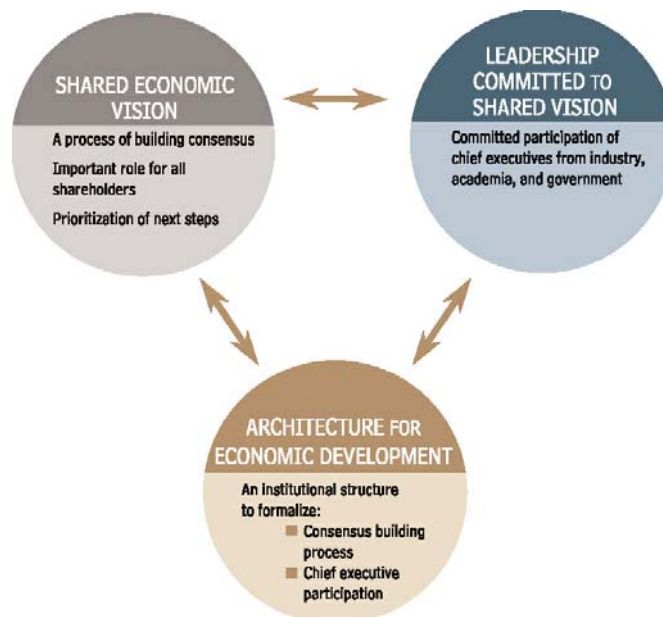
ments provide basic education, support workforce training, and build and maintain the physical infrastructure; institutions for collaboration provide information, lobby on behalf of business, help overcome collective action problems among firms, and create networking opportunities. However, it is critical that the vision is shared and the efforts are not redundant – and only strong leadership can achieve these goals. Utilizing this framework, the following section outlines how other regions have organized for and achieved action.

Leadership

Strong leadership committed to regional economic development is needed to ensure that companies, knowledge centers, governments, and collaborative institutions contribute to their full potential. To be sure, all of these organizations inevitably contribute to a regional economy in the course of their normal operations. But that contribution may fall short of its potential. Local companies often weaken their own cluster by driving out competition and trying to monopolize information and resource flows among input providers, suppliers, and customers. Universities may under-leverage their entire operation for commercialization of basic research, or make the process too cumbersome to be worthwhile. Neighboring governmental jurisdictions often have trouble achieving consensus on how to solve pressing problems with the result that they are postponed indefinitely. Institutions for collaboration may fail to perform key functions like building cross-cluster networks and facilitating the flow of ideas and innovations from knowledge centers to industry.

In the successful regions we studied, strong leaders from the private sector, universities, government, and institutions for collaboration mandated that their organizations contribute to the regional economy. They embraced the notion that “what is good for the community is good for my organization.” Most important, these leaders made development a priority: they identified weaknesses, leverageable assets, and models of success from other regions; they appointed individuals and created and supported organizations to carry out desired initiatives; they benchmarked progress; and they clearly communicated to other members in their organization that regional economic development was important and contributions would be rewarded.

Exhibit 100: Organizing for Action



Shared Vision

Numerous companies, government agencies, knowledge centers, and collaborative institutions must coordinate with each other in order to fully contribute to economic development. They must communicate their respective needs to each other, prioritize collectively, commit resources to solving these needs, and work together to streamline the delivery of resources. Yet, these organizations do not recognize one master; there is no CEO of regional economic development.

In order to achieve good coordination among many diverse groups without an overarching executive power, a shared vision of common objectives and methods is vital. This does not mean all participants agree on a detailed master plan. It does mean that influential individuals and groups broadly agree on a basic issue such as:

- The main challenges and opportunities facing a region
- That a broad array of groups (e.g., companies, clusters, knowledge centers, government agencies, community groups, and collaborative institutions) be included in solving these issues

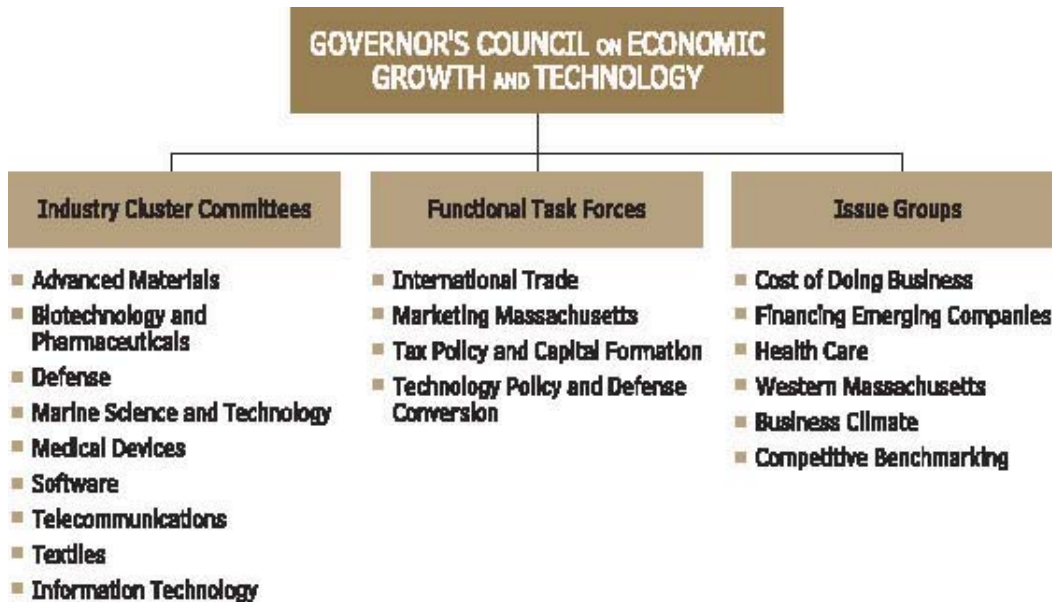
- That an organization’s (e.g., companies, universities, etc) long-term interests are tied to the health of the local economy
- That collaboration among diverse groups will be needed to compete in today’s economy

Architecture for Economic Development

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. Another method is 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, to make recommendations for policy action, and to 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. The result was an effective effort by key cluster players that assisted to improve the position of a wide array of industries – and ultimately the state of the regional economy.

Exhibit 101: Massachusetts’ Governor’s Council on Economic Growth & Technology



End Notes

1. Bob Gradeck, *Are Young People Really Fleeing the Pittsburgh Region in Droves?* Center for Economic Development website, Carnegie Mellon University.
2. PWC Money Tree, 2000 data is through first three quarters.
3. *U.S. Competitiveness 2001: Strengths, Vulnerabilities, and Innovation Priorities Report* ; national growth from \$6 billion to \$68 billion.
4. Entertainment growth in Pittsburgh is driven by household and other audio and video equipment, recorded products and other production.
5. Cluster Mapping Project at Harvard Business School, According to 1999 MSA data.
6. See “broad” and “narrow” cluster definitions in the Methodology section above.
7. Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School.
8. The Pittsburgh Technology Council provides about 130 programs and networking events per year, according to its President, Steven Zylstra.
9. Richard Florida, *Competing in the Age of Talent*; January 2000 paper.
10. Michael E. Porter, Hirotaka Takeuchi, Mariko Sakakibara, *Can Japan Compete?* New York: Perseus Books (2000).
11. See Michael E. Porter, *The Competitive Advantage of Nations*, New York: The Free Press (1990).
12. For an expanded treatment, see Chapter 7 in Michael E. Porter, *On Competition*, Harvard Business School Press (1998).
13. Michael E. Porter, Scott Stern, Council on Competitiveness, *The New Challenge to America's prosperity: Findings from the Innovation Index*, Washington, D.C.: 1999.
14. In the case of the Pittsburgh, the region is defined as the Pittsburgh MSA, which includes six counties: Allegheny, Beaver, Butler, Fayette, Washington, and Westmoreland and the Pittsburgh—West Virginia EA, which includes the Pittsburgh MSA plus 13 additional counties: four in Pennsylvania (Armstrong, Greene, Indiana and Lawrence) and nine in Virginia (Barbour, Doddridge, Harrison, Lewis, Marion, Monangalia, Preston, Taylor and Upshur).
15. 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.
16. The 1992 Input-Output Accounts measure the share of economic value traded between industries.
17. Metropolitan Initiative Forum website: Sustainable Development in the Pittsburgh Metropolitan Region.

18. Continuous casting is the process whereby molten steel is solidified into a “semifinished” billet, bloom, or slab for subsequent rolling in finishing mills. Prior to the introduction of continuous casting in the 1950s, steel was poured into stationary molds to form “ingots.” Since then, “continuous casting” has evolved to achieve improved yield, quality, productivity, and cost efficiency.
19. Bureau of the Census website.
20. Bureau of Labor Statistics, County Employment Data.
21. Cluster Mapping Project at HBS.
22. 1999 Regional Economic Revitalization Index for Southwestern Pennsylvania).
23. Council on Competitiveness, on the FRONTIER Interviews.
24. Pittsburgh Biotechnology Initiative University of Pittsburgh website.
25. U.S. Bureau of Labor Statistics; Occupational Employee Statistics.
26. The data in this paragraph is from the Cluster Mapping Project, and the Bureau of Economic Analysis, Bureau of the Census (County Business Patterns Program).
27. U.S. Bureau of Labor Statistics (BLS).
28. U.S. Census Bureau.
29. Bureau of Economic Analysis.
30. Baker Thompson website.
31. Baker Thompson website.
32. International Trade Administration, Bureau of Labor Statistics.
33. U.S. Department of Commerce, International Trade Administration, and Bureau of Labor Statistics.
34. Data source for this paragraph U.S. Department of Labor, Philadelphia Regional Office - The Curtis Center.
35. Jobs in traded industries pay about \$13,000 more per year than jobs in non-traded industries.
36. Pittsburgh has 40 available cluster data points, as fishing and fishing products have data limitations within the region.
37. Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School.
38. University of Pittsburgh WebSite; Carnegie Mellon University Website.
39. WebCASPAR Database; U.S. Bureau of Labor Statistics.
40. Interview: David Haunshell, with review of a student based research paper on R&D within the Pittsburgh region.
41. Bureau of Labor Statistics. Scientist and engineering occupational categories include: engineers and related occupations, natural scientists and related occupations, computer, mathematical, operations research, and related occupations, economists.
42. World Trade Center, Pittsburgh - website.
43. Bureau of Labor Statistics. Technician occupational categories include the technicians and technologists in the same fields listed for scientists and engineering occupations.
44. Websites; University of Pittsburgh; Carnegie Mellon University.
45. Bureau of Labor Statistics.
46. Clusters of Innovation Initiative Regional Survey™.
47. Bob Gradeck, *Are Young People Really Fleeing the Pittsburgh Region in Doves?* Center for Economic Development website, Carnegie Mellon University.
48. State Science and Technology Institute.

49. Calculated from State of Pennsylvania Department of Education statistics.
50. Pittsburgh's Education and Policy & Issues Center.
51. Pittsburgh School District annual tabulation- Public School SAT scores.
52. Calculated from NCES CCD "Agency" Database.
53. Clusters of Innovation Initiative Regional Survey™.
54. Texas Transportation Institute, Texas A&M University, 1999 Annual Mobility Report.
55. Pittsburgh Business Times 2000 Book of Lists.
56. Clusters of Innovation Initiative Regional Survey™.
57. Clusters of Innovation Initiative Regional Survey™.
58. Clusters of Innovation Initiative Regional Survey™.
59. Clusters of Innovation Initiative Regional Survey™.
60. These figures are for the Pittsburgh MSA, broad cluster definition. It is important to recognize that we use measures for the MSA and Economic Area, and for broad and narrow cluster definition. Numbers will change depending on which geographic area and cluster definition we are using.
61. Cluster Mapping Project at the Institute for Strategy and Competitiveness, Harvard Business School.
62. The Working Together Consortium.
63. A collaboration between Carnegie Mellon and UPMS Shadyside Hospital, it is a laboratory at the Robotics Institute, not to be confused with MERITS (Medical Robotics and Information Technology for Medicine and Surgery).
64. Cluster of Competitiveness interview and CASurgica website.
65. Center for Biotechnology and Bioengineering.
66. World Trade Center, Pittsburgh.
67. University of Pittsburgh Website: The Office of Technology Management link.
68. University of Pittsburgh Office of Technology Management; Cluster of Innovation interviews.
69. Broad cluster definition.
70. Cluster Mapping Project at the Institute for Strategy and Competitiveness, Harvard Business School.
71. It is important to note that not all of the employment in the research organizations sub-cluster is employment in research organizations that are focused on bio-sciences.
72. WebCASPAR database.
73. U.S. News and World Report website, 2000 Best School Ratings.
74. Clusters of Innovation Initiative Regional Survey™.
75. Pittsburgh Business Times, July 1998.
76. Clusters of Innovation Initiative Regional Survey™.
77. Clusters of Innovation Initiative Regional Survey™.
78. Clusters of Innovation Initiative Regional Survey™.
79. Pittsburgh Business Times and Monitor analysis.
80. University of Pittsburgh website; Council on Competitiveness interview.
81. Cluster Mapping Project at the Institute for Strategy and Competitiveness, Harvard Business School.
82. See page 71; interviews with Dennis Yablonsky, President of the Digital Green House; website and articles in the Pittsburgh Times.

83. Steve Zylstra, The Pittsburgh Technology Council.
84. Cluster Mapping Project at the Institute for Strategy and Competitiveness, Harvard Business School; and Monitor analysis.
85. Cluster Mapping Project at the Institute for Strategy and Competitiveness, Harvard Business School.
86. Cluster Mapping Project at the Institute for Strategy and Competitiveness, Harvard Business School.
87. PWC Money Tree Database, and Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School.
88. Pittsburgh Business Times, based on revenue growth in the three years ending 2000. Rank based on revenue percent growth over three years.
89. Clusters of Innovation Initiative Regional Survey™.
90. Clusters of Innovation Initiative Regional Survey™.
91. Clusters of Innovation Initiative Regional Survey™.
92. Clusters of Innovation Initiative Regional Survey™.
93. Council on Competitiveness interview.
94. Cluster Mapping Project at Institute for Strategy and Competitiveness, HBS.
95. J.K. Stone, cited in Gold, et al, *Technical Progress and Industrial Leadership*, 556 n.28, 550-552.
96. Thomas J. Misa, *A Nation of Steel, The Making of Modern America* Johns Hopkins Press (1995).
97. William T. Hogan, S.J., *Economic History of the Iron and Steel Industry*, DC Heath & Co. (1971).
98. American Iron and Steel Institute, Annual Statistical Reports.
99. North American Steel Industry Alliance website
100. Mini-mills melt scrap in electric furnaces to produce lower end products, primarily for the construction industry.
101. Hall, *Steel Phoenix: The Fall and Rise of the U.S. Steel Industry*, St. Martin's Press 1997.
102. *Pittsburgh Business Directory*, Dun and Bradstreet, Hoovers, Inc., Pittsburgh Business Times.
103. Cluster Mapping Project at Institute for Strategy and Competitiveness, HBS.
104. PWC Money Tree Database.
105. David Haunshell with CMU students.
106. Carnegie Mellon University website.
107. Clusters of Innovation Initiative Regional Survey™.
108. Pittsburgh Biotechnology Initiative.
109. Clusters of Innovation Initiative Regional Survey™.
110. Clusters of Innovation Initiative Regional Survey™.
111. Clusters of Innovation Initiative Regional Survey™.
112. Clusters of Innovation Initiative Regional Survey™.
113. TRW.com.
114. *Pittsburgh Business Times Book of Lists*, American City Business Journals, Vol. 20, No. 23, 12/27/00 (approximately 30% of historical VC funds have been invested locally).
115. <http://www.upmc.edu/About/Facts.htm>.

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 divided 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	Direct use of data Inc. Magazine lists companies by sales growth.	Inc. Magazine Top 500 list of high-growth companies
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 workforce	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/teacher ratios, average expenditures per student, and SAT scores	National Center for Education Statistics
Physical infrastructure	Transportation System, Communications System, Utilities	Direct use of data	Clusters of Innovation Initiative Regional Survey™ Data
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	<p>Direct use of average questionnaire response:</p> <p>How available are local research centers to use by private firms, and how frequently do they transfer technology and knowledge to the private sector?</p>	Clusters of Innovation Initiative Regional Survey, TM and interviews
Specialized talent base	<p>Direct use of average questionnaire response:</p> <p>Is there a sufficient number of qualified scientists, researchers, technicians, and business managers to sustain and grow companies in the region?</p>	Clusters of Innovation Initiative Regional Survey, TM and interviews
Specialized training	<p>Direct use of average questionnaire response:</p> <p>Do local institutions supply a sufficient number of qualified scientists, researchers, technicians, and business managers, and will this improve or worsen in the future?</p>	Clusters of Innovation Initiative Regional Survey, TM and interviews
Sophistication of demand	<p>Direct use of average questionnaire response:</p> <p>Are local customers sophisticated in their demand for new and better products, and do companies receive regular feedback from these customers?</p>	Clusters of Innovation Initiative Regional Survey, TM and interviews
Intensity of rivalry	<p>Direct use of average questionnaire response:</p> <p>How many local rivals are there in your cluster, and would you characterize competition as more intense or more mild?</p>	Clusters of Innovation Initiative Regional Survey, TM and interviews
Degree of cooperation	<p>Direct use of average questionnaire response:</p> <p>Do firms share knowledge with each other, and do they consistently contribute to cluster-wide projects and initiatives?</p>	Clusters of Innovation Initiative Regional Survey, TM and interviews
Related and supporting	<p>Direct use of average questionnaire response:</p> <p>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?</p>	Clusters of Innovation Initiative Regional Survey, TM 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 202 executives at companies and institutions throughout the region. Of the total, 129 were companies from the biotech/pharmaceutical, information technology and production technology clusters, and 73 were from regional institutions of collaboration and other non-cluster organizations (e.g., venture capital firms, banks).

The in-depth interviews were conducted by our team with 51 individuals in the Pittsburgh region. Of these, 23 were with business executives in the biotech/pharmaceutical, information technology, and production technology clusters, and 28 were with representatives from academic, government, or collaborative institutions.

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY™

Measure	Description of Rating Scale	Number of Respondents	Overall Mean	High	Neutral	Low
The cost of doing business (specifically, the cost of real estate, wages and salaries, and utilities) is...	<p>1 <i>High relative to other regions</i></p> <p>7 <i>Low relative to other regions</i></p>	202	4.4	28.7%	16.8%	54.5%
The overall quality of transportation (e.g., roads, air transport, railroads and ports) is...	<p>1 <i>Very poor relative to other regions</i></p> <p>7 <i>Very good relative to other regions</i></p>	202	3.7	33.7%	18.8%	47.5%
Specialized facilities for research (e.g., science laboratories, university research institutions and technical libraries) are...	<p>1 <i>Limited</i></p> <p>7 <i>Readily Available</i></p>	199	5.6	84.4%	9.5%	6.0%
The institutions in your region that perform basic research...	<p>1 <i>Rarely transfer knowledge to your industry</i></p> <p>7 <i>Frequently transfer knowledge to your industry</i></p>	198	4.0	42.4%	20.7%	36.9%
The communications infrastructure (including internet access) in your region...	<p>1 <i>Fails to satisfy your business needs</i></p> <p>7 <i>Fully satisfies your business needs</i></p>	201	5.2	72.6%	13.4%	13.9%
Qualified scientists and engineers in your region are...	<p>1 <i>Scarce</i></p> <p>7 <i>In ample supply</i></p>	201	4.3	52.2%	17.4%	30.3%
The available pool of skilled workers in your region...	<p>1 <i>Is too small and hinders your growth</i></p> <p>7 <i>Is sufficient to meet your growth needs</i></p>	200	3.7	36.5%	17.5%	46.0%
The overall quality of the K-12 education system is...	<p>1 <i>Very poor</i></p> <p>7 <i>Very high</i></p>	200	4.1	42.5%	22.0%	35.5%

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	Overall Mean	High	Neutral	Low
Advanced educational programs (e.g., vocational schools, colleges and/or universities)...	<p>1 <i>Provide your business with low quality employees</i></p> <p>7 <i>Provide your business with high quality employees</i></p>	201	5.2	73.1%	14.4%	12.4%
Training for computer and internet technology is...	<p>1 <i>Not available to all regional residents</i></p> <p>7 <i>Available to all regional residents</i></p>	197	5.2	75.1%	15.2%	9.6%
Regional access to risk capital (e.g. venture funds and private equity investments) is...	<p>1 <i>difficult</i></p> <p>7 <i>easy</i></p>	199	3.9	34.7%	29.6%	35.7%
The overall quality of life (e.g., climate, cultural and recreational opportunities) in the region)...	<p>1 <i>Makes recruitment and retention of employees difficult</i></p> <p>7 <i>Makes recruitment and retention of employees easy</i></p>	199	4.7	63.3%	18.1%	18.6%
The cost of living in your region...	<p>1 <i>Makes recruitment and retention of employees difficult</i></p> <p>7 <i>Makes recruitment and retention of employees easy</i></p>	199	5.4	79.4%	15.1%	5.5%
Recent economic growth in your region has...	<p>1 <i>Primarily benefited those with high wealth or high skills</i></p> <p>7 <i>Helped everyone</i></p>	198	4.0	41.9%	17.2%	40.9%
Regional customers for your business's products/services are...	<p>1 <i>Unsophisticated and undemanding</i></p> <p>7 <i>Sophisticated and demanding</i></p>	126	4.5	51.6%	24.6%	23.8%
Regional customers for your business' products/services have...	<p>1 <i>No special needs that impact your product offering</i></p> <p>7 <i>Special needs that impact your product offering</i></p>	130	4.3	50.8%	18.5%	30.8%

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	Overall Mean	High	Neutral	Low
Feedback from regional customers to improve your business's products/services is...	<p>1 <i>Infrequent and does not reveal the need for new features or enhanced performance</i></p> <p>7 <i>Frequent and reveals the need for new features or enhanced performance</i></p>	126	4.0	42.1%	17.5%	40.5%
State and regional regulations affecting your business are...	<p>1 <i>Inappropriate and hinder your firm's ability to succeed</i></p> <p>7 <i>Appropriate and assist you firm's ability to succeed</i></p>	191	3.8	30.9%	27.2%	41.9%
The state and regional environmental standards and safety regulations...	<p>1 <i>Are lax</i></p> <p>7 <i>Are strict</i></p>	135	5.1	62.2%	32.6%	5.2%
Investment in R&D is...	<p>1 <i>Discouraged by state and regional taxes and incentives</i></p> <p>7 <i>Encouraged by state and regional taxes and incentives</i></p>	196	3.7	26.5%	34.2%	39.3%
State and local government support for investment in R&D (e.g. funding business incubators, creating consortia)...	<p>1 <i>Is scant</i></p> <p>7 <i>Is ample</i></p>	200	3.6	30.0%	26.5%	43.5%
Government's overall responsiveness and ability to work with the needs of business is...	<p>1 <i>Low</i></p> <p>7 <i>High</i></p>	198	3.2	25.3%	17.7%	57.1%
The number of regional competitors for your business in your region is...	<p>1 <i>Low</i></p> <p>7 <i>High</i></p>	134	3.4	39.6%	1.5%	59.0%
Regional competition in your industry is...	<p>1 <i>Mild</i></p> <p>7 <i>Intense</i></p>	132	3.8	43.2%	9.8%	47.0%

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...	<p>1 <i>Mostly not available inside your region</i></p> <p>7 <i>Mostly available inside your region</i></p>	133	4.0	45.1%	13.5%	41.4%
Regional specialized suppliers of your business's materials, components, machinery, and services are...	<p>1 <i>Of very low quality</i></p> <p>7 <i>Comparable with the best quality elsewhere</i></p>	131	4.8	60.3%	21.4%	18.3%
Regional specialized suppliers assist your firm with new product and process development ...	<p>1 <i>Infrequently</i></p> <p>7 <i>Frequently</i></p>	132	3.5	32.6%	18.9%	48.5%
Businesses in your region...	<p>1 <i>Hide information from other firms even when there is not a competitive reason to do so</i></p> <p>7 <i>Share information openly with other businesses</i></p>	127	3.8	24.4%	41.7%	33.9%
Your cluster...	<p>1 <i>Is still emerging, with a narrow range of firms and institutions involved</i></p> <p>7 <i>Is well developed with a broad range of firms and institutions involved</i></p>	131	2.9	14.5%	18.3%	67.2%
Relationships between firms and organizations in your cluster...	<p>1 <i>Do little to assist your R&D efforts</i></p> <p>7 <i>Are very important to your R&D efforts</i></p>	129	2.6	11.6%	16.3%	72.1%
Associations and organizations that represent your cluster...	<p>1 <i>Do not exist or are ineffective</i></p> <p>7 <i>Exist and effectively promote the interests of the cluster</i></p>	131	3.2	26.0%	19.1%	55.0%
Firms in your cluster...have no preference for the geographic location of their business partners...	<p>1 <i>Have no preference for the geographic location of their business partners</i></p> <p>7 <i>Prefer to work with firms located in the region</i></p>	125	3.0	18.4%	24.0%	57.6%

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	<p>1 <i>Infrequently share knowledge</i></p> <p>7 <i>Frequently share knowledge</i></p>	127	2.8	14.2%	20.5%	65.4%
Firms and organizations in your cluster... (contribution to cluster-wide programs)	<p>1 <i>Rarely contribute to cluster-wide programs</i></p> <p>7 <i>Frequently contribute to cluster-wide programs</i></p>	127	2.8	14.2%	23.6%	62.2%
Firms and organizations in your cluster...(willingness to accept new members)	<p>1 <i>Are unwilling to accept new members into cluster activities and organizations</i></p> <p>7 <i>Treat entrepreneurs, start-ups, and new companies as full partners in all aspects of cluster cooperation</i></p>	128	3.6	24.2%	38.3%	37.5%
Firms in your cluster...(advantage in perceiving buyer trends—see coding for scale end points)	<p>1 <i>Have no advantage in perceiving new buyer trends compared to firms who are not in a cluster</i></p> <p>7 <i>Perceive new buyer trends more rapidly than your competitors who do not operate thin a cluster</i></p>	125	3.4	17.6%	40.0%	42.4%

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

Measure	Description of Rating Scale	Number of Respondents	Overall 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?	<p>1 <i>Very poor location</i></p> <p>7 <i>Very good location</i></p>	200	4.2	33.5%	18.5%	48.0%

Measure	Description of Rating Scale	Number of Respondents	<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?	<p>1 <i>Less than 25%</i></p> <p>2 <i>25% to 50%</i></p> <p>3 <i>50 to 75%</i></p> <p>4 <i>Greater than 75%</i></p> <p>9 <i>Not applicable</i></p>	126	2.4%	4.8%	20.6%	72.2%
What proportion of commercialization is done within your firm, as opposed to by/with any of the institutions listed above?	<p>1 <i>Less than 25%</i></p> <p>2 <i>25% to 50%</i></p> <p>3 <i>50 to 75%</i></p> <p>4 <i>Greater than 75%</i></p> <p>9 <i>Not applicable</i></p>	129	5.4%	4.7%	16.3%	73.6%

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY™

Measure	Description of Rating Scale	Number of Respondents	Average	Frequently	Sometimes	Never
develop: Universities	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	133	1.6	6.0%	46.6%	47.4%
develop: Community Colleges	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	131	1.2	0.0%	17.6%	82.4%
develop: Public or Private Research Centers	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	131	1.3	3.1%	26.7%	70.2%
develop: Regional Customers	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	131	2.0	18.3%	61.1%	20.6%
develop: Other Firms in Your Industry	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	132	1.8	11.4%	58.3%	30.3%
develop: Regional Suppliers	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	130	1.8	10.0%	56.9%	33.1%
develop: Venture Capital Firms	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	131	1.2	3.1%	13.0%	84.0%
develop: Business Incubators	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	131	1.1	0.8%	11.5%	87.8%
develop: Industry or Cluster Associations	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	130	1.5	4.6%	42.3%	53.1%
develop: Business Assistance Centers (SBA)	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	131	1.4	3.8%	31.3%	64.9%

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY™

Measure	Description of Rating Scale	Number of Respondents	Average	Frequently	Sometimes	Never
commerce: Universities	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	129	1.4	3.1%	29.5%	67.4%
commerce: Community Colleges	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	125	1.1	0.8%	10.4%	88.8%
commerce: Public or Private Research Centers	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	126	1.3	2.4%	23.0%	74.6%
commerce: Regional Customers	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	127	1.8	12.6%	51.2%	36.2%
commerce: Other Firms in Your Industry	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	126	1.7	7.9%	50.8%	41.3%
commerce: Regional Suppliers	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	126	1.6	4.0%	48.4%	47.6%
commerce: Venture Capital Firms	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	126	1.2	1.6%	12.7%	85.7%
commerce: Business Incubators	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	126	1.1	1.6%	11.1%	87.3%
commerce: Industry or Cluster Associations	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	126	1.4	4.8%	31.7%	63.5%
commerce: Business Assistance Centers (SBA)	1 <i>Never</i> 2 <i>Sometimes</i> 3 <i>Frequently</i>	126	1.3	3.2%	23.8%	73.0%

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY™

Measure	Description of Rating Scale	Number of Respondents	Average	Satisfied	Neutral	Unsatisfied
sat: Universities	1 <i>Unsatisfied</i> 7 <i>Satisfied</i> DK or NA	93	3.9	32.3%	29.0%	38.7%
sat: Community Colleges	1 <i>Unsatisfied</i> 7 <i>Satisfied</i> DK or NA	65	3.3	20.0%	38.5%	41.5%
sat: Public or Private Research Centers (salk, scripps)	1 <i>Unsatisfied</i> 7 <i>Satisfied</i> DK or NA	76	3.7	23.7%	42.1%	34.2%
sat: Regional Customers	1 <i>Unsatisfied</i> 7 <i>Satisfied</i> DK or NA	101	4.7	55.4%	29.7%	14.9%
sat: Other Firms in Your Industry	1 <i>Unsatisfied</i> 7 <i>Satisfied</i> DK or NA	101	4.3	46.5%	32.7%	20.8%
sat: Regional Suppliers	1 <i>Unsatisfied</i> 7 <i>Satisfied</i> DK or NA	100	4.3	44.0%	34.0%	22.0%
sat: Venture Capital Firms	1 <i>Unsatisfied</i> 7 <i>Satisfied</i> DK or NA	65	3.0	12.3%	38.5%	49.2%
sat: Business Incubators	1 <i>Unsatisfied</i> 7 <i>Satisfied</i> DK or NA	58	3.0	13.8%	37.9%	48.3%
sat: Industry Associations	1 <i>Unsatisfied</i> 7 <i>Satisfied</i> DK or NA	79	3.7	31.6%	34.2%	34.2%
sat: Business Assistance Centers (RTA, SBA)	1 <i>Unsatisfied</i> 7 <i>Satisfied</i> DK or NA	76	3.6	31.6%	27.6%	40.8%

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 <i>Not at all helpful</i> 5 <i>Critically helpful</i>	169	2.5	24.3%	23.1%	52.7%
enterpren: University technology transfer offices	1 <i>Not at all helpful</i> 5 <i>Critically helpful</i>	165	2.2	14.5%	26.7%	58.8%
enterpren: Regional industry or cluster councils	1 <i>Not at all helpful</i> 5 <i>Critically helpful</i>	166	2.4	19.3%	28.3%	52.4%
enterpren: National trade associations	1 <i>Not at all helpful</i> 5 <i>Critically helpful</i>	168	2.6	22.0%	33.3%	44.6%
enterpren: Economic development organizations	1 <i>Not at all helpful</i> 5 <i>Critically helpful</i>	169	2.3	17.2%	26.6%	56.2%
estab co: University-based networking organizations	1 <i>Not at all helpful</i> 5 <i>Critically helpful</i>	167	2.3	18.0%	21.6%	60.5%
estab co: University technology transfer offices	1 <i>Not at all helpful</i> 5 <i>Critically helpful</i>	164	2.1	14.6%	19.5%	65.9%
estab co: Regional industry or cluster councils	1 <i>Not at all helpful</i> 5 <i>Critically helpful</i>	165	2.4	15.8%	34.5%	49.7%
estab co: National trade associations	1 <i>Not at all helpful</i> 5 <i>Critically helpful</i>	168	2.7	24.4%	33.9%	41.7%
estab co: Economic development organizations	1 <i>Not at all helpful</i> 5 <i>Critically helpful</i>	165	2.4	20.0%	22.4%	57.6%

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 <i>Disagree</i> 7 <i>Agree</i>	199	3.2	22.1%	9.5%	68.3%
Intense local competition between companies tends to contribute positively to the standard of living of the average citizen	1 <i>Disagree</i> 7 <i>Agree</i>	196	4.4	53.6%	18.9%	27.6%
Companies that compete against each other in the region should establish closer ties and cooperative agreements than they have now	1 <i>Disagree</i> 7 <i>Agree</i>	195	4.4	49.2%	26.2%	24.6%
Entry of a new competitor in the region benefits the business environment	1 <i>Disagree</i> 7 <i>Agree</i>	198	3.0	18.7%	13.1%	68.2%
Companies in close geographic proximity often end up sharing information that they otherwise would not	1 <i>Disagree</i> 7 <i>Agree</i>	194	4.4	53.6%	18.0%	28.4%
Presence of intense local competition between companies tends to foster innovation	1 <i>Disagree</i> 7 <i>Agree</i>	196	5.4	84.7%	4.6%	10.7%
Where possible, companies should seek to train workers through cooperative training programs, rather than on their own	1 <i>Disagree</i> 7 <i>Agree</i>	195	4.8	59.5%	23.6%	16.9%
For most firms, the benefits of having local competitors outweigh the costs	1 <i>Disagree</i> 7 <i>Agree</i>	196	4.3	47.4%	24.0%	28.6%

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
Projects that require cooperation and collaboration between firms in my region tend to cost more than they return	1 <i>Disagree</i> 7 <i>Agree</i>	192	3.7	24.0%	32.8%	43.2%
Employees at every level of a company should be encouraged to exchange non-proprietary information with their peers at other firms	1 <i>Disagree</i> 7 <i>Agree</i>	197	4.0	43.7%	21.3%	35.0%
It is possible for companies to collaborate and compete at the same time	1 <i>Disagree</i> 7 <i>Agree</i>	198	5.3	78.3%	8.6%	13.1%
Cooperation between local firms has contributed directly to the prosperity of the region as a whole	1 <i>Disagree</i> 7 <i>Agree</i>	195	4.4	50.8%	27.7%	21.5%
Companies are worse off when they have to compete with other local companies to attract and retain skilled workers	1 <i>Disagree</i> 7 <i>Agree</i>	197	4.0	41.1%	13.2%	45.7%
Intense local competition between companies tends to help them increase productivity	1 <i>Disagree</i> 7 <i>Agree</i>	198	5.2	81.3%	6.6%	12.1%
Firms in clusters...are better prepared to compete vs. isolated competitors	1 <i>Disagree</i> 7 <i>Agree</i>	194	5.1	73.7%	16.0%	10.3%
Firms in clusters...benefit indirectly when other firms in the cluster succeed	1 <i>Disagree</i> 7 <i>Agree</i>	194	5.1	73.2%	18.6%	8.2%

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 <i>Agree</i> 7 <i>Disagree</i>	193	3.9	31.1%	32.6%	36.3%
Firms in clusters...innovate at the same rate as firms not in clusters	1 <i>Agree</i> 7 <i>Disagree</i>	195	3.3	18.5%	20.0%	61.5%
Firms in clusters...are more susceptible to downturns in their industry	1 <i>Agree</i> 7 <i>Disagree</i>	193	3.8	24.4%	36.3%	39.4%

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 Pittsburgh to your firm's ability to innovate?	1 <i>Not at all beneficial</i> 5 <i>Critically beneficial</i>	194	2.3	13.4%	26.9%	59.7%
In five years, how beneficial do you think your physical location in Pittsburgh will be to your firm's ability to innovate?	1 <i>Not at all beneficial</i> 5 <i>Critically beneficial</i>	134	2.3	14.9%	26.9%	58.2%

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 <i>Hardly at all</i> 2 <i>Some impact</i> 3 <i>Significant impact on business model</i> 4 <i>Fundamentally changed business model</i>	135	2.2	5.9%	48.9%	25.9%	19.3%

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY

Measure	Description of Rating Scale	Number of Respondents	Average	Not Important	Important	More Important
Promote world-class primary and secondary education	1 <i>Not at all important</i> 5 <i>Critically important</i>	138	4.2	4.3%	15.2%	80.4%
Promote specialized education and training programs to upgrade worker skills	1 <i>Not at all important</i> 5 <i>Critically important</i>	138	3.9	9.4%	13.0%	77.5%
Implement tax reform to encourage investment in innovation (e.g., R&D tax credits)	1 <i>Not at all important</i> 5 <i>Critically important</i>	197	4.0	2.5%	24.9%	72.6%
Speed up regulatory approval processes in line with product life-cycles	1 <i>Not at all important</i> 5 <i>Critically important</i>	192	3.4	19.3%	34.9%	45.8%
Simplify compliance procedures for government regulations (e.g., one-stop filing, websites, etc)	1 <i>Not at all important</i> 5 <i>Critically important</i>	195	3.6	13.8%	28.2%	57.9%
Reform liability laws to stimulate and reward next generation product innovation and safety	1 <i>Not at all important</i> 5 <i>Critically important</i>	195	3.4	19.0%	34.4%	46.7%
Promote antitrust legislation to encourage competition	1 <i>Not at all important</i> 5 <i>Critically important</i>	194	2.4	55.7%	27.8%	16.5%
Support the particular needs of start-up companies (access to capital, incubators, management training)	1 <i>Not at all important</i> 5 <i>Critically important</i>	199	3.6	19.1%	25.6%	55.3%
Strengthen and modernize intellectual property protections (patents, copyrights) at home and abroad	1 <i>Not at all important</i> 5 <i>Critically important</i>	195	3.4	18.5%	32.8%	48.7%
Provide services to assist and promote regional exports	1 <i>Not at all important</i> 5 <i>Critically important</i>	198	3.1	29.8%	33.8%	36.4%

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	197	3.5	17.3%	31.0%	51.8%
Assist in attracting suppliers and service providers from other locations	1 Not at all important 5 Critically important	195	2.9	35.9%	29.7%	34.4%
Promote universal computer literacy	1 Not at all important 5 Critically important	195	3.3	21.5%	33.8%	44.6%
Government support for funding of specialized research institutes, labs, etc.	1 Not at all important 5 Critically important	194	2.9	37.1%	32.5%	30.4%
Catalyze partnerships among government, industry and universities.	1 Not at all important 5 Critically important	195	3.3	22.6%	32.3%	45.1%
Improve transportation and other physical infrastructure	1 Not at all important 5 Critically important	196	3.8	10.7%	22.4%	66.8%
Increase funding for university-based research	1 Not at all important 5 Critically important	195	3.0	33.8%	32.3%	33.8%

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

Measure	Description of Rating Scale	Number of respondents	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	134	8.2%	75.4%	6.0%	10.4%

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY™

Measure	Description of Rating Scale	Number of respondents	End Consumer Manufactured Product	Business Service	Intermediate Input	Technical/IT Support Product
Which best describes your primary line of business	<ol style="list-style-type: none"> 1 <i>End-consumer Manufactured Product</i> 2 <i>Business Service</i> 3 <i>Intermediate Input</i> 4 <i>Technical/IT support product</i> 5 <i>Other</i> 	95	54.7%	18.9%	6.3%	20.0%

Measure	Description of Rating Scale	Number of respondents	prior to 1960	1961-1980	1981-1990	1991-1995	1996-present
When was your organization founded?	enter year	106	18.9%	10.4%	15.1%	21.7%	34.0%

Measure	Description of Rating Scale	Number of respondents	0 to 3 years	3 to 10 years	more than 10 years
When did your firm first establish a presence in your region	enter year	134	76.1%	20.1%	3.7%

Measure	Description of Rating Scale	Number of respondents	0-10	11-50	51-200	201+
Approximate Number of Employees	enter number	132	26.5%	37.9%	22.7%	12.9%

Measure	Description of Rating Scale	Number of respondents	1	2	3	4	5	6
Revenue Category	<ol style="list-style-type: none"> 1 <i><\$1 million</i> 2 <i>1 to 10 mill</i> 3 <i>11 to 50 mill</i> 4 <i>51 to 100 mill</i> 5 <i>101 to 300 mill</i> 6 <i>300 mill plus</i> 	104	18.4%	43.3%	20.2%	8.7%	6.7%	2.9%

Measure	Description of Rating Scale	Number of Respondents	Spend Less	Spend Same	Spend More
Relative to your competitors in your industry, how would you describe your firm's expenditures on R&D?	<ol style="list-style-type: none"> 1 <i>Spend far less</i> 2 <i>Spend somewhat less (on a % basis) than competitors</i> 3 <i>Spend about the same (on a % basis) than competitors</i> 4 <i>Spend somewhat more (on a % basis) than competitors</i> 5 <i>Spend far more (on a % basis) than competitors</i> 	119	31.1%	26.9%	42.1%

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY™

Measure	Description of Rating Scale	Number of respondents	1	2	3	4	5
Please estimate your company's average annual revenue growth over the past three years	1 <i>Negative to 0%</i> 2 <i>1 to 10%</i> 3 <i>11 to 20%</i> 4 <i>20 to 100%</i> 5 <i>Over 100%</i>	127	22.0%	26.8%	26.8%	20.5%	3.9%

Measure	Description of Rating Scale	Number of Respondents	Worse than Average	Average	Better than Average
Looking back over the past 5 years, how would you rate your company's performance relative to your company's competitors?	1 <i>Among the best in the industry</i> 2 <i>Significantly better than average</i> 3 <i>Somewhat better than average</i> 4 <i>Just about average</i> 5 <i>Somewhat worse than average</i> 6 <i>Significantly worse than average</i> 7 <i>Among the worst in the industry</i>	121	9.9%	14.0%	76.0%

Measure	Description of Rating Scale	Number of Respondents	1	2	3	4
Which best describes your position in your firm?	1 <i>Owner, president, CEO</i> 2 <i>Sr. Executive/Sr. Official</i> 3 <i>Manager</i> 4 <i>Other</i>	201	66.7%	18.9%	4.0%	10.5%

Measure	Description of Rating Scale	Number of respondents	1	2	3	4	5
Education (Check highest completed)	1 <i>Some secondary school</i> 2 <i>Secondary school</i> 3 <i>Some college</i> 4 <i>College graduate</i> 5 <i>Graduate Degree</i>	202	0.5%	2.5%	6.9%	44.1%	46.0%

Measure	Description of Rating Scale	Number of respondents	1	2	3	4	5
Age	1 <i>20-29</i> 2 <i>30-39</i> 3 <i>40-49</i> 4 <i>50-59</i> 5 <i>60 or older</i>	202	5.4%	9.4%	33.2%	36.1%	15.8%

Measure	Description of Rating Scale	Number of respondents	Newly Arrived	Established	Longtime Resident
How long have you lived in this area?	enter years	175	12.6%	24.0%	63.4%

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	132	72.0%	43.2%
Quality of transportation	132	31.1%	23.5%
Specialized facilities for research	132	17.4%	6.1%
Qualified scientists and engineers	132	24.2%	25.8%
Transfer of knowledge from research institutions	132	24.2%	7.6%
Communications infrastructure	132	30.3%	9.8%
Available pool of skilled workforce	132	30.3%	53.8%
Quality of K-12 education	132	19.7%	21.2%
Sourcing of employees from advanced educational programs	132	19.7%	15.9%
Access to capital	132	24.2%	34.8%
Demanding regional customers that provide feedback	132	10.6%	3.8%
Specialized needs of regional customers	132	15.9%	4.5%
State/local regs for production processes and products/services	132	3.0%	20.5%
State and regional environmental / safety regs	132	4.5%	28.8%
State and regional tax and incentives for investment in R & D	132	7.6%	21.2%
Predictability of government policies	132	3.0%	26.5%
Government's overall responsiveness to the needs of business	132	5.3%	46.2%
Level of competition in your industry	132	16.7%	29.5%
Quality and in-region location of your suppliers	132	20.5%	9.8%
Assistance from regional suppliers for new product and process development	132	9.8%	6.1%
Relationships between firms and organizations in your cluster	132	9.8%	9.8%
Participation with regional institutions in R & D efforts	132	12.1%	8.3%
Overall quality of life for employees	132	18.9%	3.0%

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY™

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)	Count	Number of Respondents	Percent of Total Respondents that Checked this Option
Eimpact: Increased efficiency of supplier replenishment	115	37	32.2%
Eimpact: Allowed firm to reduce reliance on distributors	115	21	18.3%
Eimpact: Improved internal knowledge flow	115	76	66.1%
Eimpact: Improved quality of information on customers	115	72	62.6%
Eimpact: Enlarged client base	115	45	39.1%
Eimpact: Improved worker productivity	115	46	40.0%
Eimpact: Improved customer and investor access to information about firm	115	57	49.6%
Current reason: Proximity to regional suppliers to your industry	177	31	17.5%
Current reason: Proximity to regional client base	177	54	30.5%
Current reason: Happenstance (Chance/Luck)	177	61	34.5%
Current reason: Prior relationship with local company	177	58	32.8%
Current reason: Access to skilled labor	177	48	27.1%
Current reason: Tax incentives	177	2	1.1%
Current reason: Air/Water Quality	177	1	0.6%
Current reason: Low traffic congestion	177	7	4.0%
Current reason: Proximity to regional research and development centers	177	53	29.9%
Current reason: Business-friendly political environment	177	8	4.5%
Current reason: Low cost of labor	177	15	8.5%
Current reason: Access to raw materials	177	16	9.0%
Current reason: Proximity to competing firms in your industry	177	11	6.2%
Current reason: Housing Affordability	177	14	7.9%
Current reason: Low cost of commercial land	177	21	11.9%
Current reason: Proximity to executives principal residence	177	75	42.4%
Next 5 years: Proximity to regional suppliers to your industry	170	17	10.0%
Next 5 years: Proximity to regional client base	170	54	31.8%
Next 5 years: Access to skilled labor	170	84	49.4%
Next 5 years: Tax incentives	170	85	50.0%

RESULTS OF CLUSTERS OF INNOVATION INITIATIVE REGIONAL SURVEY™

	Count	Number of Respondents	Percent of Total Respondents that Checked this Option
Next 5 years: Air/Water Quality	170	2	1.2%
Next 5 years: High income inequality	170	13	7.6%
Next 5 years: Proximity to regional research and development centers	170	21	12.4%
Next 5 Years: Traffic Congestion	170	23	13.5%
Next 5 years: Business-friendly political environment	170	69	40.6%
Next 5 years: High cost of labor	170	44	25.9%
Next 5 years: Low access to raw materials	170	7	4.1%
Next 5 years: Distance from competing firms in your industry	170	18	10.6%
Next 5 years: High cost of housing	170	3	1.8%
Next 5 years: High cost of commercial land/property	170	5	2.9%

appendix 3

CONTRIBUTORS TO THE PITTSBURGH STUDY

In addition to the Pittsburgh regional leaders that we mentioned in the acknowledgements, The Council on Competitiveness, The Monitor Group and ontheFRONTIER would like to personally thank the following community and business leaders in Pittsburgh for contributing their time and insights to the Clusters of Innovation Initiative as part of the interview process, as well as the 202 survey respondents in the region.

Tilden Bennett	DynaVox Systems, Inc.	Elizabeth Lynn	Mccune Foundation
Arthur A. Boni	U. of Pittsburgh of Tech Management	James Maher	University of Pittsburgh
Sanjay Chopra	OnlineChoice.com	David McCormick	Free Markets
Peyton Collins	American Robot Corporation	Barbara McNeese	Chamber of Commerce
Thomas Detre	UPMC	Lawrence E. Moch, Jr.	Mellon Ventures
Steve DiAntonio	National Robotics Engineering Consortium	Thomas Murrin	Duquesne University
Tom Emerson	Donald H. Jones Center	Dave Nelson	CoManage Software
Lee Erlichman	Cardia Telecom	Paul Overby	ABB Daimler-Benz Transportation, Adtranz
David Evans	CLARITECH Corp.	Tim Parks	Pittsburgh Regional Alliance
Ben Fischer	Carnegie Mellon University	Casey Porto	Tech Transfer CMU
Richard Florida	Carnegie Mellon University	Jim Roddey	Allegheny County Chief Executive
Bill Gernert	CMU Manufacturing Assistance Center	Alan J. Russell	Pittsburgh Tissue Engineering Initiative
Jeffrey Gilbert	PPG Industries	Sean D.S. Sebastian	Birchmere Investments
Bruce Glick	eVProducts, Inc.	Cliff Shannon	Small Business Council
Doug Goodall	Innovation Works	Jack Shilling	Allegheny Technologies
Mike Herman	Three Rivers Area Labor Mgmt Comm	Richard Simmons	Allegheny Teledyne
David Hounshell	Carnegie Mellon University	Rick Stafford	Allegheny Conf. on Comm. Development
Bill Hulley	Adams Capital Management	Jeff Stayer	ABB Daimler-Benz Transportation, Adtranz
Branko Jaramaz	CASurgica, Inc.	Joel Tarr	Carnegie Mellon University
Mark Kamlet	Carnegie Mellon University	Timothy Tassone	Hallmark / Tassone Advertising
Dwight Keating	Claude Worthington Benedum Foundation	Jerry Thompson	Ketchum (PR)
Brian Kelley	Heinz Endowments	John Thorne	CMU
Paul L. Kornblith	Precision Therapeutics, Inc.	Konrad Weis	Bayer
Mark Kryder	Seagate Research	Rick Winter	U. Pittsburgh, Katz School of Business
Alfred Kuehn, Ph.D.	Management Science Associations, Inc.	Dennis Yablonsky	Digital Greenhouse
Helen Lemon	Arthur Andersen	Steve Zylstra	Pittsburgh High Technology

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 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.

