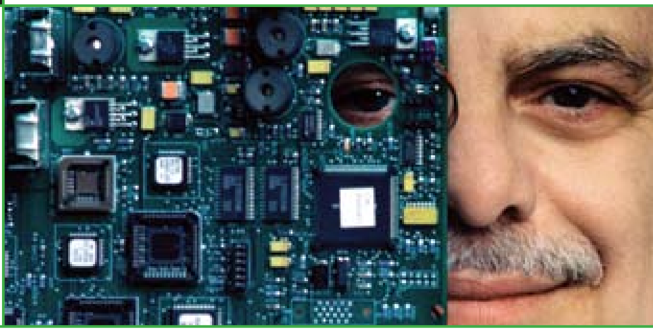
Milken Institute

Pittsburgh Technology Strategy

November 2006

by Perry Wong,
Benjamin Yeo
and Ross DeVol



MILKEN INSTITUTE

Pittsburgh Technology Strategy

Research Report

Presented to
The Greater Oakland Keystone Innovation Zone

Completed by
Milken Institute

By
Perry Wong
Benjamin Yeo
Ross DeVol

1250 Fourth Street, Santa Monica, California 90401
www.milkeninstitute.org

NOVEMBER 2006

Acknowledgements

The Milken Institute would like to acknowledge the support of the Greater Oakland Keystone Innovation Zone in providing the assistance and support to this project, without which this project would not have become a reality. We are especially grateful to Don Smith and Timothy White for their comments and advice throughout the course of the project.

In addition, we would like to thank our colleagues for their assistance in various ways. Of note, the contributions of Dinah McNichols, editor, and Armen Bedroussian, senior research analyst, deserve considerable recognition.

Cover photographs of "New Technology," "Point at Dusk," and "Duquesne Incline" are reprinted with permission from the *Pittsburgh Post-Gazette*. The cover photograph of the Mellon Institute is reprinted with permission from the Department of Chemistry, Carnegie Mellon University.

The Milken Institute is an independent economic think tank whose mission is to improve the lives and economic conditions of diverse populations in the U.S. and around the world by helping business and public policy leaders identify and implement innovative ideas for creating broad-based prosperity. We put research to work with the goal of revitalizing regions and finding new ways to generate capital for people with original ideas.

We do this by focusing on *human capital* – the talent, knowledge and experience of people, and their value to organizations, economies and society; *financial capital* – innovations that allocate financial resources efficiently, especially to those who ordinarily would not have access to it, but who can best use it to build companies, create jobs and solve long-standing social and economic problems; and *social capital* – the bonds of society, including schools, health care, cultural institutions and government services, that underlie economic advancement.

By creating ways to spread the benefits of human, financial and social capital to as many people as possible – *the democratization of capital* – we hope to contribute to prosperity and freedom in all corners of the globe.

We are nonprofit, nonpartisan and publicly supported.

Table of Contents

List of Tables

List of Figures

Executive Summary

Look at the economic base of every advanced industrial nation, and you'll find lower manufacturing employment figures, but substantially higher production output. Over the past three decades, every region that has enjoyed economic growth anticipated the need to redirect its efforts toward the development of a knowledge-based economy comprising high-tech industries (with both manufacturing and service sectors) that recruit and retain the best human capital they can afford.

The foundation for this new economy, based in knowledge (and information) and enriched with knowledge assets (colleges, universities and research centers), requires viable information systems, innovation facilitators, a supportive institutional regime and human capital.[1] The demand for its high-tech "knowledge goods," as well as monetary value of those goods and the salaries of the knowledge workers who produce them, reflects the importance of high technology in today's world.[2] (In fact, income disparities are increasingly shaped by gaps in knowledge and information capacity.[3]) Therefore, leveraging human capital — talent, education, skills and experience — is crucial for planning and generating economic development.

It was, of course, heavy manufacturing that made Pittsburgh prosperous for much of its modern history. And when the steel industry collapsed in the 1970s and the region's manufacturing base deteriorated, Pittsburgh continued to be well served by Carnegie Mellon University and the University of Pittsburgh — the former strong in computing and engineering, the latter acclaimed for life-sciences research and its organ transplant institute. Yet even with such an established knowledge base, the Pittsburgh region has proved unable to achieve its aspirations and foster a high-tech economy that would rival the area's previous economic achievements. In fact, the metropolitan-area economy has been in decline.

In 2003, according to that year's Milken Institute Tech Pole Index — the measure of a region's high-tech industry concentration and growth in relation to other U.S. Metropolitan Statistical Areas (MSAs) — Pittsburgh ranked 39th in a field of 100. The index also measures each MSA's contribution to U.S. high-tech output, or real GDP. San Jose, California, in the heart of Silicon Valley and No. 1 on the index, scored a perfect score of 100. In contrast, Pittsburgh scored 4.28.

Nor did Pittsburgh fare much better in the Milken Institute's Best Performing Cities Index, an annual compilation based on such factors as job-, wage- and salary growth, and technology growth, over a five-year period. From 1999 to 2005, Pittsburgh ranked low in overall economic performance; 2003 was the only year the region appeared in the top 100 MSAs for this index, and even that was at the 96th position. The region scored lowest in 2000, at 188. These rankings suggest that the region lacks the triggers to simulate growth, despite its boomtown legacy.

For this study, we selected five MSAs — Baltimore, Indianapolis, Phoenix, Seattle and St. Louis — with which to compare and contrast Pittsburgh's high-tech employment and industry growth rate, for example, and local trends in venture capital investment and university spending in research and development. Each region has some similarity to Pittsburgh in economic makeup. They are all, for example, midsized metros in transition that are competing in the global arena. The result of the study, which uses both quantitative and qualitative assessments, is a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis of Pittsburgh's high-tech base.

The quantitative analysis was broken down into seven components: the innovation pipeline, education infrastructure, business climate, industry development capacity, industry concentration, industry productivity and industry cuts (or sectors). We analyzed the strengths and weaknesses of Pittsburgh's high-tech industry and compared the tech base with those of the five other MSA cities.

Our findings show that while Pittsburgh has great development potential, it lacks the energy to take the region to the next level of economic performance. This may be due to a number of factors:

- aversion to risk
- lack of productivity growth
- high corporate tax rates
- low high-tech wage-income base
- lack of anchor firms
- poor entrepreneurial environment
- low immigration
- low workforce development

Finally, we break down Pittsburgh's high-tech industry into 25 industry "cuts", or sectors. Examining the cuts' strengths, weaknesses, opportunities and threats, we propose recommendations for five of them. In brief, the recommendations are to:

- develop policies that leverage the university talent by encouraging university startups and primary research and development;
- develop policies that encourage venture capital investments at the corporate level;
- maintain the status quo and develop policies to increase output;
- aggressively support local high-tech development and make Pittsburgh a favorable destination for expansion or relocation;
- increase enrollment for relevant programs at colleges and universities, and develop scholarship programs and local industry networks for relevant university programs.

The qualitative analysis examines Pittsburgh's leadership and business environment, and includes examples of best practices from other MSAs. A summary of the qualitative SWOT assessment follows:

Strengths:

Strong, university-based knowledge assets; active grassroots political leadership; active incubators; the presence of established high-tech firms; low personal state and local tax burdens.

Weaknesses:

High risk aversion, negative migration dynamics; no real policy for high-tech development from previous political leadership; lack of political collaboration; unfavorable corporate tax structure.

Opportunities:

Newly elected political leadership; scholarship programs in Pennsylvania; proximity to high-tech talent; university collaborations.

Threats:

Pittsburgh's financial deficit, competition from more economically favorable regions; drain of the knowledge base; aging population.

In addition, we offer proposals as starting points for the implementation of strategies:

- Initiate technology scholarship programs at leading Pittsburgh universities.
- Develop and offer business services, targeted to opportunity areas, to help high-tech businesses connect with national venture capital firms and other companies.
- Increase lobbying efforts so that the new regional leadership places industry development high on its agenda.

A more aggressive shift toward the knowledge-based economy offers the potential for Pittsburgh to regain its growth of the Fifties. This SWOT analysis lays the groundwork for planning initiatives that have the potential to reinvigorate the area's dampened economy.

SWOT Analysis

Introduction

The world's advanced industrial nations experienced a fundamental economic change three decades ago. In the 1970s, they began to shift their emphasis from manufacturing to service industries and increased their industrial dependency on technical information and knowledge.[4] To remain viable, local governments and businesses, for example, found it necessary to use information and communications technologies, thus facilitating computerization and the so-called digital revolution.[5] The current demand for technical knowledge, the monetary value placed on it and the salaries paid to knowledge workers all reflect the immense societal value of the new knowledge industries.[6] Income disparities, and regional economic growth, are increasingly shaped by gaps in knowledge and innovation capacities.[7]

Four factors, each of which must be sustainable, form the basis of the knowledge economy: information systems, innovation facilitators, a supportive institutional regime and human capital.[8] Of these, human capital (ideas and innovation) lies at the center of every link and interdependence among firms and industries.[9]

However, just as important as the availability of human capital (high-tech workers) is the ability to attract and retain that capital and to generate an ongoing flow of intellectual capital.[10] Countries like Korea, Singapore and Taiwan, for example, are poor in natural resources but have fared better than their resource-rich neighbors Thailand, China, Malaysia and Indonesia. Their success is due to their ability to leverage human capital assets. They were quick to focus their economic policies on creating vibrant R&D environments for scientists and entrepreneurs.[11] India, too, learned to leverage human capital to build a robust software industry: Seven India Institutes of Technology (administered overall by an ITT Council at whose head is the national Minister of Human Resource Development) provide a steady stream of engineers and entrepreneurs into the country's work force.[12]

Across the United States, regional economies are feeling the effects of technological innovation and assimilation, making the leveraging of human capital assets a requisite among economic development initiatives.[13] The process, however, requires analysis and collaboration among agencies, and between the private and public sectors.

Pittsburgh MSA

The Pittsburgh region's economy has been dampened by a number of factors over the past 25 years. Global shifts in heavy industry and manufacturing affected both population and economic growth. Even with two world-class universities, Carnegie Mellon University and the University of Pittsburgh, that provide a well-established knowledge base, the population remains flat and the region's economic performance lags behind the national economy in some sectors.

Carnegie Mellon is ranked No. 14 worldwide in science and engineering by the U.K.'s *Times Higher Education Supplement (THES)* in its 2005 "World University Rankings." In overall university rankings, THES rated Carnegie Mellon 21st in the United States. According to the university's web site, *U.S. News & World Report* ranked Carnegie Mellon second nationwide in management information systems and fifth in computer engineering. Also last year, *The Wall Street Journal* rated the graduate school of business second nationally for its information technology programs and fifth for its entrepreneurship academics. "More than 70 startup companies in the Pittsburgh region have emerged from research conducted by Carnegie Mellon faculty and students," the university web site notes, "in fields such as computer science, software engineering and robotics."[14]

The University of Pittsburgh, one of the country's oldest universities, is renowned for its life-sciences research. This was where a young Jonas Salk, then director of the medical school's Virus Research Lab, developed a vaccine for polio.[15] This past December, the National Medal of Science, the nation's highest scientific honor, was awarded to Thomas Starzl, "the father of transplantation" and a Distinguished Service Professor of Surgery at the university's medical school. It was Starzl who made Pittsburgh the organ transplant capital of the world.[16]

The two schools have a history of innovative collaboration. In 2000, the National Sciences Foundation awarded the Pittsburgh Supercomputing Center, a joint operation of the University of Pittsburgh, Carnegie Mellon University and Westinghouse Electric Company, a three-year, $45 million grant to create, with help from Compaq Computer Corp., an open-source Terascale Computing System (TCS), the world's most powerful nonmilitary computer system.

Despite these initiatives and assets, Pittsburgh scored 141st in the Milken Institute's 2004-2005 Best Performing Metros Index, slightly ahead of St. Louis, which ranked 144th. Baltimore, which also has highly respected universities and enjoyed a strong economy in the 1950s, came in at 60th. Clearly, Pittsburgh's economic performance is not in sync with its exceptional knowledge base. The region has failed to leverage its assets and potential.

Project Objectives

Our objectives are to provide an analysis of Pittsburgh's high-tech industry and to recommend strategies to develop that industry for regional economic growth.

The best strategy, of course, involves a clearly defined focus, and this research justifies key areas in which to formulate development initiatives.

Summary of Analysis

In Appendixes A and B, we provide a breakdown of the high-tech industry into numerous manufacturing and service sectors. Our analysis is based on these definitions.

Appendix C provides the data sources for the Strengths, Weaknesses, Opportunities, Threats (SWOT) analysis.

The following two tables offer key indicators we used for all six MSAs, including population, high-tech employment, the percentage of high-tech employment, wages for high-tech workers, university R&D activity, high-tech GDP and productivity, the cost of living and the cost of doing business.

Table 1: Tabulated Summary of High-Tech Economy by MSA - Human Resources

MSA	Population 2004 est. (mil)	High-Tech Employment (ths)	Percentage High-Tech Employment 2004 (%)	High-Tech Wages per Worker (2004) ($ths)	Key Univ.
Baltimore	2.64	82.9	8.1	$65.40	John Hopkins U. U. of Maryland
Indianapolis	1.62	58.1	7.8	$55.20	Indiana U.
Phoenix	3.72	117.7	8.4	$71.80	Arizona State U.
Pittsburgh	2.4	62.7	6.4	$65.10	Carnegie Mellon U. U. of Pittsburgh
Seattle	3.17	185.3	16.7	$79.50	U. of Washington
St. Louis	2.79	80.1	7.1	$63.00	Washington U.

Source: Economy.com, U.S. Census Bureau

Table 2: Tabulated Summary of High-Tech Economy by MSA - Performance

	HT GDP ($Bil)	HT Productivity ($Ths)	HT Growth (I=1990)	Overall Growth (I=1990)
Baltimore	$9.30	$112.39	80.75%	44.50%
Indianapolis	$8.40	$144.16	140.79%	84.93%
Phoenix	$19.20	$163.00	210.47%	146.09%
Pittsburgh	$7.50	$118.84	112.12%	43.72%
Seattle	$27.60	$148.75	101.11%	69.04%
St. Louis	$8.90	$111.48	55.00%	41.60%

Source: Economy.com, U.S. Census Bureau, AUTM

The Milken Institute Tech Pole Index illustrates the high-tech industry concentration and growth for MSAs, and their U.S. rankings. It is a composite measure, based on the percentage of national high-tech output, or GDP, multiplied by the high-tech location quotient (LQ). Location quotients are calculated as a measure of a region's economic base in a specific industry, with respect to a larger context. In this case, the larger region is the United States. Scoring in the tech pole index can range from 0.0 to 100.0. A high score means the region is exerting a strong technology gravitational pull.

In 2003, the latest rankings compiled by the Milken Institute, all six MSAs ranked among the top 50 metros. In terms of high-tech industry growth and concentration, San Jose, in first place here, scored a perfect 100.0. Note the difference between San Jose and Washington, D.C., which ranked second yet scored just 54.0; and the even greater disparity between San Jose and the remaining MSAs. Among those, Seattle and Phoenix led, at third and eighth, with scores of 42.1 and 18.8, respectively. Pittsburgh scored 39th, with a score of 4.3, slightly ahead of last-place St. Louis, which scored 4.1.

Pittsburgh's high-tech location quotient (LQ) and high-tech real GDP were lower than four of the benchmarked MSAs. The scores also show large differences in LQ and real GDP between Seattle (and San Jose) at the high end and Indianapolis, Baltimore, Pittsburgh and St. Louis, at the bottom.

Table 3 Milken Institute Tech Pole Index, 2003

Rank	Score	MSA	Rank	Score	MSA
1	100	San Jose, CA	26	9.469	Minneapolis-St. Paul, MN-WI
2	54.027	Washington, DC-MD-VA-WV	27	8.36	Kansas City, MO-KS
3	42.061	Seattle-Bellevue-Everett, WA	28	7.681	Wichita, KS
4	40.049	Los Angeles-Long Beach, CA	29	7.367	Boise City, ID
5	32.87	Boston, MA	30	6.708	Huntsville, AL
6	32.445	Dallas, TX	31	6.481	Indianapolis, IN
7	26.906	Portland-Vancouver, OR-WA	32	6.437	New Haven-Bridgeport-Stamford, CT
8	18.82	Phoenix-Mesa, AZ	33	6.408	Baltimore, MD
9	16.05	Atlanta, GA	34	5.964	Fort Worth-Arlington, TX
10	15.93	Chicago, IL	35	5.57	Nassau-Suffolk, NY
11	15.148	Philadelphia, PA-NJ	36	5.278	Colorado Springs, CO
12	15.116	Orange County, CA	37	5.192	Tampa-St. Petersburg-Clearwater, FL
13	14.688	San Diego, CA	38	4.366	Rochester, NY
14	13.682	San Francisco, CA	39	4.283	Pittsburgh, PA
15	13.302	New York-Newark, NY-NJ-PA	40	4.174	Ventura, CA
16	13.302	Albuquerque, NM	41	4.102	St. Louis, MO-IL
17	12.686	Denver, CO	42	4.085	Tucson, AZ
18	12.146	Detroit, MI	43	3.919	Salt Lake City-Ogden, UT
19	12.105	Austin-San Marcos, TX	44	3.651	Sacramento, CA
20	11.894	Raleigh-Durham-Chapel Hill, NC	45	3.22	Melbourne-Titusville-Palm Bay, FL
21	11.541	Oakland, CA	46	3.131	Bergen-Passaic, NJ
22	10.931	Houston, TX	47	3.051	Cincinnati, OH-KY-IN
23	10.661	Newark, NJ	48	3.005	San Antonio, TX
24	10.651	Middlesex-Somerset-Hunterdon, NJ	49	2.834	Orlando, FL
25	9.538	Boulder-Longmont, CO	50	2.801	Hartford, CT

Source: Milken Institute

To assess the tech pole in terms of a region's overall economic performance, we turned to the Milken Institute's Best Performing Cities Index. It measures growth in jobs, wages and salaries, and growth over a five-year period. Such numbers are increasingly relevant in a knowledge-based economy; the best performing cities have top economic performance and create the most jobs.[17]

In the same year (2003), Phoenix performed well economically. It enjoyed a good rate of job growth, 2.80 percent (11th) and high-tech GDP growth (15th), and ranked 43rd among the best performing cities.

However, even though Seattle rated third in the tech pole index, it ranked outside the top 100 in the index of best performing cities. Its high-tech GDP was dropping (80th), yet it enjoyed a very strong high-tech location quotient of 250 (sixth). It suffered a very low rate of wage growth (179th) and job growth (151st) yet still managed to finish at 138th. Seattle's good location quotient and a solid percentage (17.32) of its work force in high-tech industry contributed to its economic performance. The workforce percentage dropped from 18.68 percent in the previous year, but Seattle's other strengths remained a driving force.

Looking at its overall economic performance, Pittsburgh ranked consistently below Seattle, Phoenix and Baltimore. In fact, in indexes compiled by the Institute from 1999 to 2005, Pittsburgh was listed just once in the top 100 MSAs, in 2003, and then at 96th. That year, Pittsburgh experienced a strong GDP growth (indexed to 1997 and 2001). In all other years, the region performed below the other benchmarked MSAs, with the exception of St. Louis. A summary of ratings from 1999 to 2005 follows.

Table 4: Milken Institute Ranks of Best Performing MSAs, 1999-2005

MSA/Ranks	1999	2000	2001	2002	2003	2004	2005
Pittsburgh	111	188	193	132	96	132	141
Baltimore	137	187	107	81	91	56	60
Indianapolis	41	40	52	74	101	60	104
Phoenix	20	24	28	17	43	3	15
Seattle	1	13	74	92	138	94	127
St Louis	77	202	217	170	186	151	144

Source: Milken Institute

Pittsburgh's low ranking, consistently within the bottom two MSAs, is largely attributable to the slow rate of job growth. As shown in the following table, the region ranked 41st nationally, with a rate of job growth reaching only 10 percent from 1990 to 2002. This was far below the 55 percent for Phoenix and 20 percent for Indianapolis.

Pittsburgh's rankings were lowest in 2000 and 2001. Ironically, during this period when the state was focusing efforts on regional economic development, the Pittsburgh ranking dropped from 40th to 44th.[18] Based on reports from the U.S. Department of Housing and Urban Development, the median family income for Pennsylvania's metropolitan areas increased by just 40 percent between 1989 and 2001, or 20 percent below the national average.[19] Thus, while the state was actively implementing efforts to boost the economy, it is clear that these efforts were not immediately effective. We explain this further in qualitative assessment. In contrast, Seattle's ranking was very good, at No. 13, with its wage growth indexed to 1993. Of course, Seattle also has a large high-tech industry base.

Pittsburgh's position rose sharply in 2002, when Comcast Corp., the largest cable company in the United States, acquired AT&T's broadband cable systems and entered the Pittsburgh market, where it acquired regional offices through the acquisition.[20] The following year, Pittsburgh again enjoyed marked GDP growth in its high-tech industry. Its growth, indexed to 1997, ranked 48th nationally; indexed to 2001, it ranked 32nd. In addition, the region enjoyed a high wage growth, indexed to 2000, at 72nd nationwide. Baltimore fared slightly better because of its high indexed growth in salaries, but its industry base remained moderately low, at 113.

Then in 2004 and 2005, Pittsburgh's position dropped to 167th, its rate of job growth having shrunk to -0.57 percent from 2003 to 2004. In 2004, the region suffered large-scale, high-profile job losses that lowered confidence in the area. This may have led to increased out-migration and a slight decrease in population.[21] Phoenix, on the other hand, showed strong job growth and a robust tech industry base.

Table 5: Ranked MSAs by Job Growth Rate (Non-Farm employment)
1990 to 2002

Rank	MSA	State	Job Growth Rate
1	Las Vegas	Nevada	90%
2	Austin	Texas	70%
3	Mesa-Phoenix	Arizona	55%
4	Colorado Springs	Colorado	43%
5	San Antonio	Texas	39%
6	Atlanta	Georgia	38%
7	Dallas	Texas	38%
8	Nashville-Davidson	Tennessee	37%
9	Tucson	Arizona	37%
10	Denver	Colorado	36%
11	Charlotte	North Carolina	35%
12	Jacksonville	Florida	35%
13	Albuquerque	New Mexico	34%
14	Fort Worth	Texas	32%
15	Houston	Texas	30%
16	Sacramento	California	30%
17	San Diego	California	28%
18	Oklahoma City	Oklahoma	26%
19	Portland	Oregon	26%
20	Tulsa	Oklahoma	26%
21	Minneapolis	Minnesota	25%
22	Columbus	Ohio	25%
23	Omaha	Nebraska	25%
24	Kansas City	Missouri	24%
25	Fresno	California	23%
26	El Paso	Texas	21%
27	Indianapolis	Indiana	20%
28	Memphis	Tennessee	20%
29	Miami	Florida	19%
30	Oakland	California	19%
31	Seattle	Washington	19%
32	San Jose	California	18%
33	Washington,	DC	18%
34	Virginia Beach	Virginia	17%
35	Wichita	Kansas	14%
36	Milwaukee	Wisconsin	13%
37	New Orleans	Louisiana	12%
38	Boston	Massachusetts	11%
39	Chicago	Illinois	11%
40	Detroit	Michigan	10%
41	Pittsburgh	Pennsylvania	10%
42	Baltimore	Maryland	9%
43	St. Louis	Missouri	8%
44	San Francisco	California	8%
45	Philadelphia	Pennsylvania	7%
46	Cleveland	Ohio	7%
47	New York	New York	2%
48	Honolulu	Hawaii	0%
49	Long Beach/Los Angeles	California	-0.90%

Sources: US Department of Labor, The Allegheny Institute for Public Policy

Pittsburgh is home to seven Fortune 500 companies, listed in the chart below with their corresponding 2003 revenues. On average, the 2005 rankings are down from 2004. Although Alcoa Inc. has revenue higher than the national average of $14.93 billion, just four companies earned revenues higher than the national median of $8.19 billion.

From these, Pittsburgh shows potential for growth (with the seven companies) but fails to sustain it (declining ranks and low revenue). As our analyses in subsequent sections show, the region in fact has few facilitators for sustainability. This is clear from the charts: a sudden rise from 2001 to 2003, followed by a sharp decline that brought the region to a ranking lower than it held in 1999.

Table 6: Fortune 500 Companies in Pittsburgh

Company	Rank 2005	Rank 2004	Revenue 2003 ($Bil)
Alcoa Inc	86	82	21.728
United States Steel Corp	209	264	9.458
H J Heinz Co	213	194	9.328
PPG Industries Inc	236	233	8.756
PNC Financial Services Group Inc	309	277	5.969
Mellon Financial Corp	385	350	4.55
Wesco International Inc	490	461	3.287
National Average			14.931
National Median			8.193

Source: USA Today

Baltimore is similar to Pittsburgh in several ways; both regions have renowned universities and underwent economic industrial booms in the 1950s. However, over the seven-year period, and with the exception of university R&D assets, Baltimore ranks higher overall.

The tech pole and the best performing cities indexes summarize Pittsburgh's national position. And while there are many areas to address for remedy, the high-tech industry deserves special attention for this reason: Regions with greater concentrations of high-tech industries perform better economically.[22] More important, MSAs experiencing the best growth rates share a common characteristic: They attract and nurture high-tech clusters that can leverage knowledge assets for commercialization and expansion. This is the key to sustained economic health.

Industry conditions can be improved for the short term with shrewd planning, but university-based assets cannot be changed overnight, and Pittsburgh's greatest asset — and chief advantage over potential competitors — lies in the entrenched strength of its universities.

We analyzed the 25 industry cuts, or sectors, within Pittsburgh's high-tech industry. Using data that capture industry trends from 1990 to 2004 and tech-firm presence, we targeted specific industries within those sectors and reduced the list further to those demonstrating clear strengths, weaknesses, opportunities and threats. We recommend key focus areas for each cut in the shortlist.

The qualitative assessment of Pittsburgh also highlights key regional strengths, weaknesses, opportunities and threats. The local knowledge base again shows up as a strength that is not being sufficiently leveraged because of weaknesses in the industrial and political environment. At the same time, grassroots political leadership shows tremendous activity, and we see strengths in the availability of early risk capital and business coaching from the nonprofit Innovation Works and other tech-based economic development providers.

Knowledge-Base Analysis

I. Innovation Pipeline

The following table provides a summary of strengths and weaknesses, and their corresponding ranks in Pittsburgh's innovation pipeline. (The innovation pipeline consists of knowledge-base assets, such as universities and venture capital.)

1. A **high strength among peers** (strength) is an attribute where Pittsburgh ranks first or second.
2. A **low weakness among peers** (weakness) is an attribute where Pittsburgh ranks fifth or sixth.
3. A **moderate strength among peers** (moderate strength) is an attribute where Pittsburgh ranks third.
4. A **moderate weakness among peers** (moderate weakness) is an attribute where Pittsburgh ranks fourth.

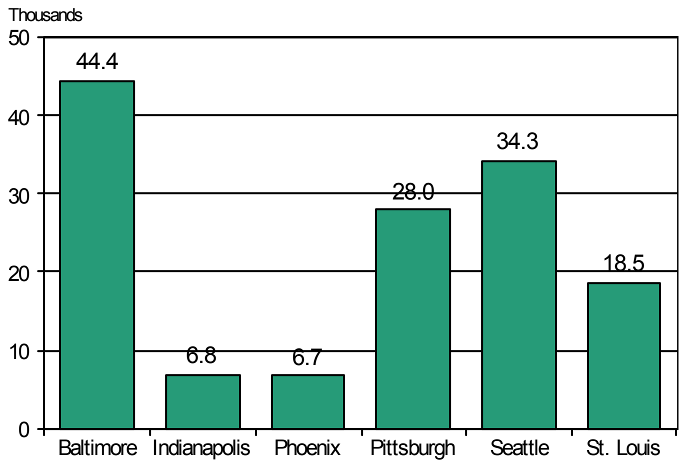
As in the previous MSA comparisons, it is clear that similar economic makeups do not result in similar performances. Overall, Pittsburgh does not leverage its knowledge-base assets as well as the other five MSAs.

Table 7: Innovation Pipeline – Summary of Strengths and Weaknesses

	Strength	Moderate Strength	Moderate Weakness	Weakness
University startups	√			
University patents filed 96-03	√			
University patents issued 96-03	√			
University R&D assets	√			
Corporate R&D assets			√	
R&D expenditure		√		
University licenses executed 96-03			√	
Students enrolled for credit			√	
High tech economic base				√
No. of VC Investments 05			√	
Sum of VC Investments 05				√
Average VC investment/investor 05			√	
Maximum VC Investment 05			√	

Pittsburgh does show considerable strengths in the academic side of its innovation pipeline, ranking third for publications (figure 1). This is a moderate strength, yet the number of publications is considerably greater than in Phoenix, Indianapolis and St. Louis.

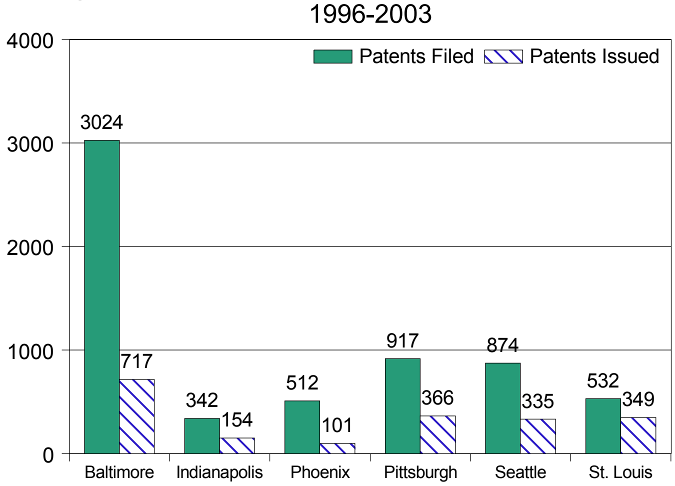
Figure 1: MSA Total Publications
1998-2002



Source: CEST

In terms of patents filed and issued (figure 2), Pittsburgh again shows academic strengths. At about 40 percent, its rate of issued patents (patents issued per patent filed) was considerably higher than Baltimore's (24 percent) and Phoenix's (20 percent). Indianapolis scored 45 percent, St. Louis 66 percent and Seattle 38 percent.

Figure 2: Patents Filed and Issued at Universities
1996-2003

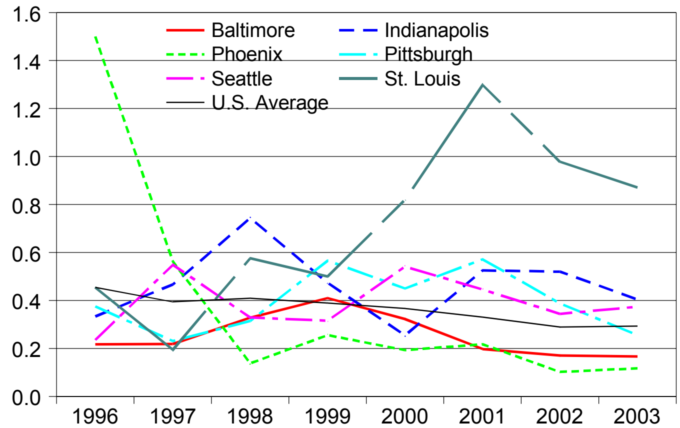


Source: AUTM

The calculations are based on total patents filed and issued between 1996 and 2003; the cumulative total is more important than rates for specific years because the number of patents issued in a given year may not include just the patents filed that year. (Although the computation of an annual patent issuing rate is problematic, it can be used to gauge relative R&D quality.)

Pittsburgh shows considerable R&D activity, and the overall quality is verified by its high patent issuing rate (figure 3). In fact, the rate surpassed the national average from 1999 to 2002. More important, the steady rates of Pittsburgh and Seattle show that these two cities have sustainable R&D.

Figure 3: Annual Patents Issuance Rate by Univ.
1996-2003

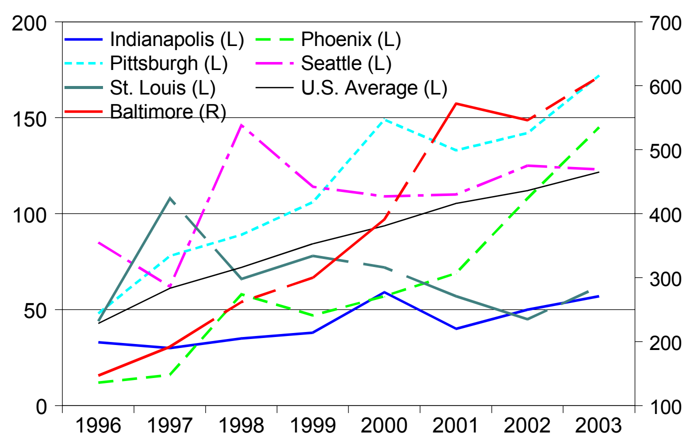


Source: AUTM

From 1996 through 2003, all universities increased their patent filings (figure 4); as of 2001, universities were filing on average more than 100 patents per year.

As expected, Baltimore filed a high number of patents every year. Pittsburgh filed fewer, between 48 and 172, but showed a trend of increased patent filing. Overall, its filing rate is also slightly higher than the peer MSAs.

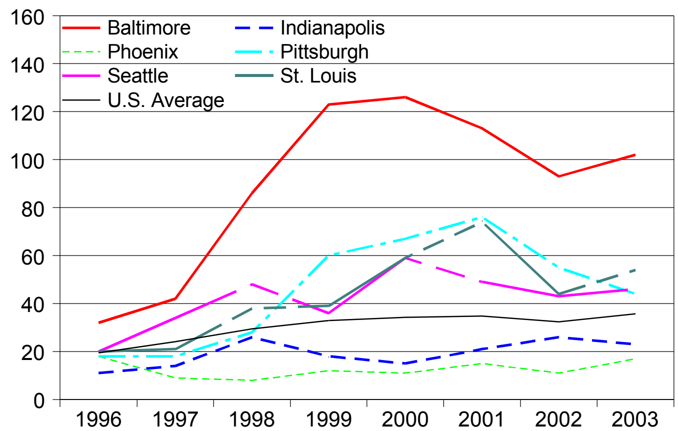
Figure 4: Annual Patents Filed by Universities
1996-2003



Source: AUTM

In terms of patents issued (figure 5), Pittsburgh's R&D strengths show up: Issued patents jumped in 1998 and remained higher than for the other benchmarked MSAs, except Baltimore, until 2003.

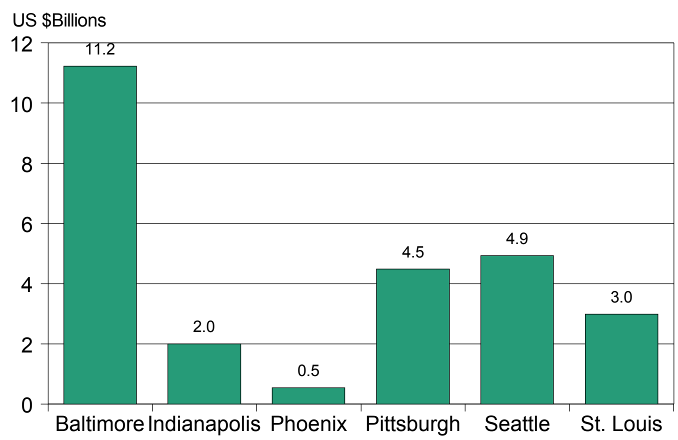
Figure 5: Annual Patents Issued to Universities
1996-2003



Source: AUTM

Pittsburgh's university R&D expenditure (figure 6) was a moderate strength for the years 1996 to 2003. At more than $4 billion, the metropolitan area trailed Seattle closely and scored substantially better than Phoenix, Indianapolis and St. Louis. However, Baltimore's R&D expenditure was considerably greater.

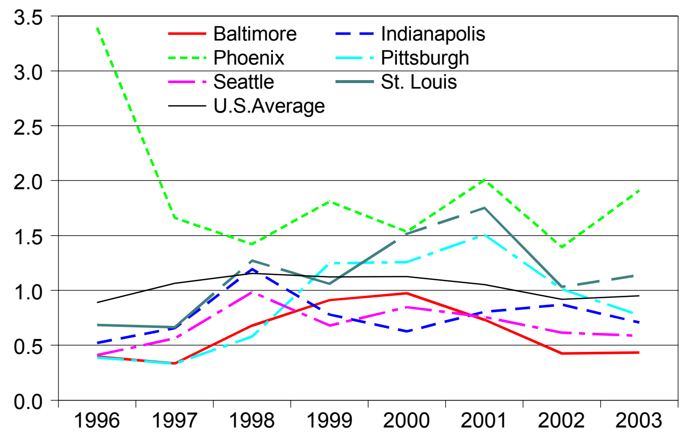
Figure 6: University R&D Expenditure
1996-2003



Source: AUTM

To determine the effectiveness of R&D expenditure, we look at the average number of patents issued per $10 million in R&D expenditure (figure 7). Pittsburgh exceeded the national average in 1999 but fell below in 2003. Phoenix and St. Louis performed better for the same period.

Figure 7: Avg. Patents Issued per $10 mil. R&D Exp.
1996-2003

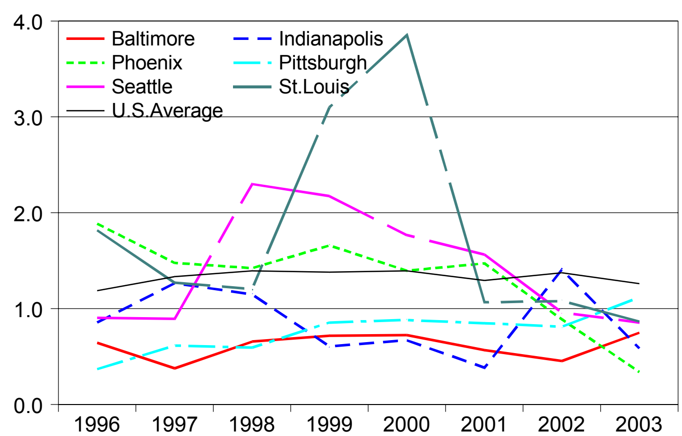


Source: AUTM

The average licensing of patent rights executed per $10 million in R&D expenditure (figure 8) shows the extent to which regions leverage the products of their R&D. Pittsburgh ranked below the national average.

This finding is important. It may indicate that university patents do not see commercialization. On the other hand, between 1998 and 2001 (the peak and initial downturn of the dot-com boom), Seattle — which ranked consistently below the national average in terms of patents issued —executed more licenses than the national average. Seattle is quick to catch on to economic trends, and its research is efficient and cost-effective because of commercialization.

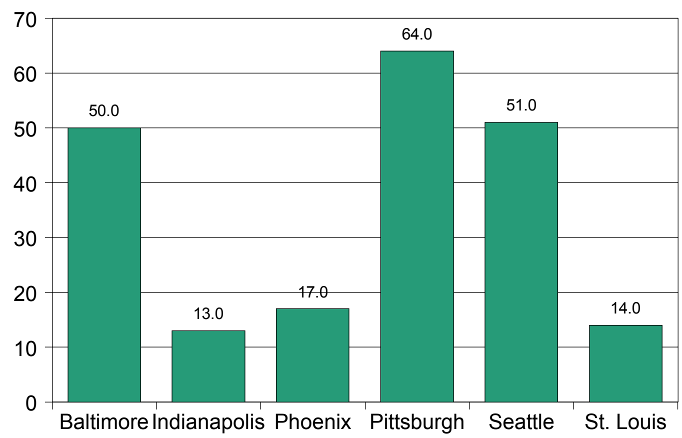
Figure 8: Avg. Lic. Executed per $10 mil. R&D Exp.
1996 to 2003



Source: AUTM

Pittsburgh led in university venture capital startups (AUTM data, figure 9). Despite spending $6.74 billion less than Baltimore in university R&D, Pittsburgh produced 25 percent more VC startups. Seattle and Pittsburgh spent roughly the same amount on university R&D, but again Pittsburgh produced 25 percent more VC start-ups. Local university-based growth potential could surpass Baltimore's and even be better than that of Seattle, which led the six MSAs in economic growth.

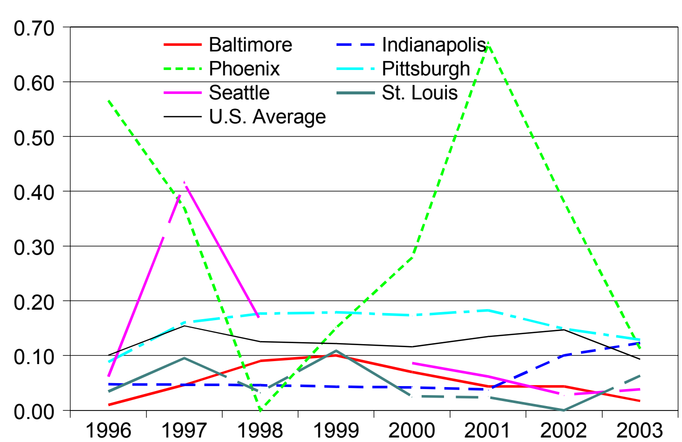
Figure 9: University VC Startups
1996-2003



Source: AUTM

Pittsburgh's university VC startups (figure 10) were close to the national average of between 0.1 and 0.2 start-up per $10 million expended in R&D. In fact, the region performed consistently well in this regard, compared to Baltimore, Indianapolis and St. Louis. Overall, the trend reinforces the argument that Pittsburgh's R&D strengths are stable and not easily removed from the region.

Figure 10: Avg. U. VC Starts per $10 mil. R&D Exp.
1996-2003



Source: AUTM

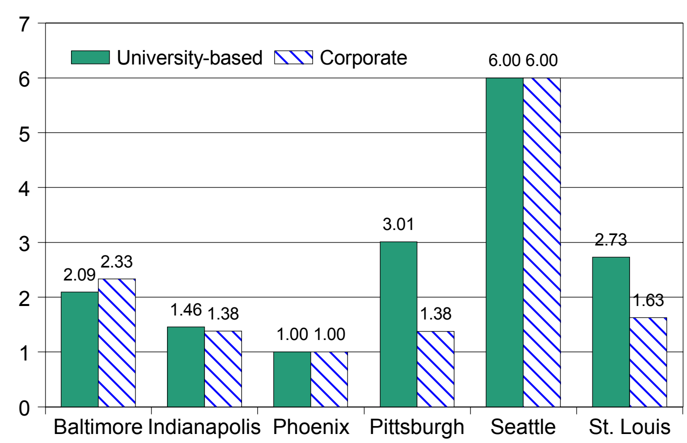
Pittsburgh's university R&D assets ranked second among the MSAs, higher even than Baltimore's. The measure of university R&D assets is computed by multiplying the rate of patents issued by the licensing revenue per patent and total R&D expenditure.

The measurement of corporate R&D assets is not so straightforward. It is determined by a composite measure of sales and the number of R&D service workers. This method is limited, but research has shown that sales and employment are significant positive determinants of corporate R&D investment for the information technology (IT) industry.[23] Because R&D investment of firms reflects their respective knowledge capital, we used this measure as a proxy because of data limitations that do not allow as rigorous a computation as for university R&D assets. We used employment in the R&D service industry to compute corporate R&D, instead of employment in general.

Figure 11 shows standardized scores of university-based and corporate R&D assets for the six MSAs. The university-based assets are based on cumulative data from 1996 and 2003; corporate assets are derived from 2004 data.

Pittsburgh showed strengths in university R&D but lagged behind Baltimore, Seattle and St. Louis in corporate R&D. Again, despite the strong number of university VC startups, Pittsburgh's licenses executed (with respect to research dollars expended) remained low. The sales and employment figures were also not on par. Again, Pittsburgh is not sufficiently leveraging its university R&D assets.

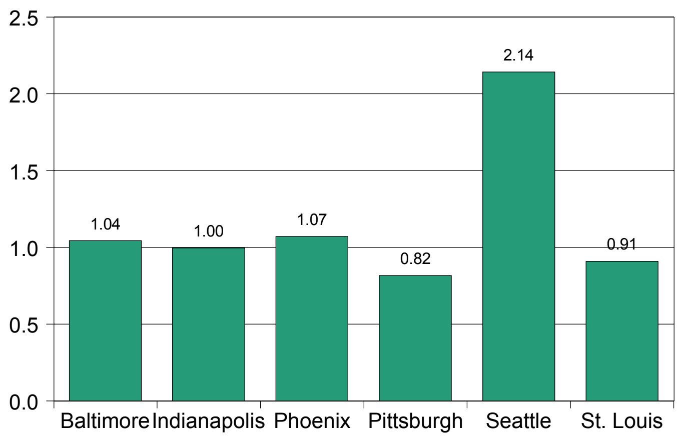
Figure 11: Univ.-Based and Corporate R&D Assets
Standardized Scores



Source: AUTM, Selectoryonline.com, Economy.com

We use location quotients (LQs) to determine the economic base of a region's high-tech industries relative to that of the United States in general. From figure 12, we see that Pittsburgh's base fell below the national level and, in last place, constitutes a weakness. This is a major concern since the high-tech base is the key to sustained economic growth. To reiterate, MSAs experiencing the best growth rates attract and nurture high-tech clusters that can leverage knowledge assets for commercialization and expansion. This is the key to sustained economic health.

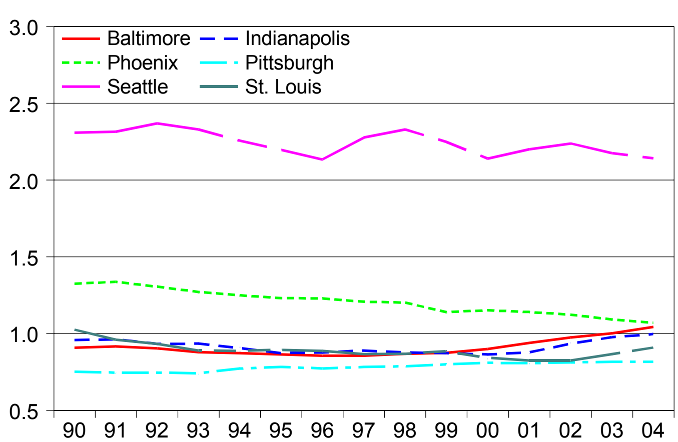
Figure 12: High-Tech Location Quotients
2004



Source: Milken Institute, Economy.com

Figure 13 illustrates the high-tech location quotient trends from 1990 to 2004. Pittsburgh's location quotients for the 14-year period remained consistently below the national average, set at 1.0. Baltimore, meanwhile, showed signs of growth as it intersected the national average in 2003 and hit 1.04 in 2004. Note that Pittsburgh's high-tech LQ remained very weak among its peers throughout the period.

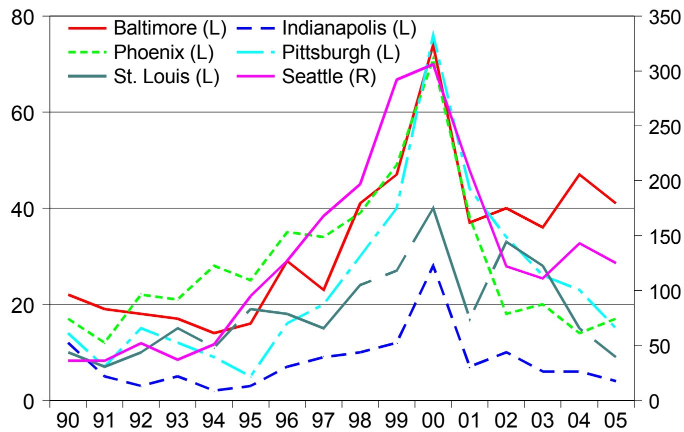
Figure 13: High-Tech LQ Trends
1990-2004



Source: Economy.com

For all MSAs, the numbers of VC investments (figure 14) follow a similar pattern. The numbers increased in the late 1990s and then dropped. This comes as no surprise since the IT boom led to increased investments and the dot-com crash resulted in a decline. The only exception is Indianapolis, which saw no sharp relative increase in VC investments.

Figure 14: Number of VC Investments
1990-2005

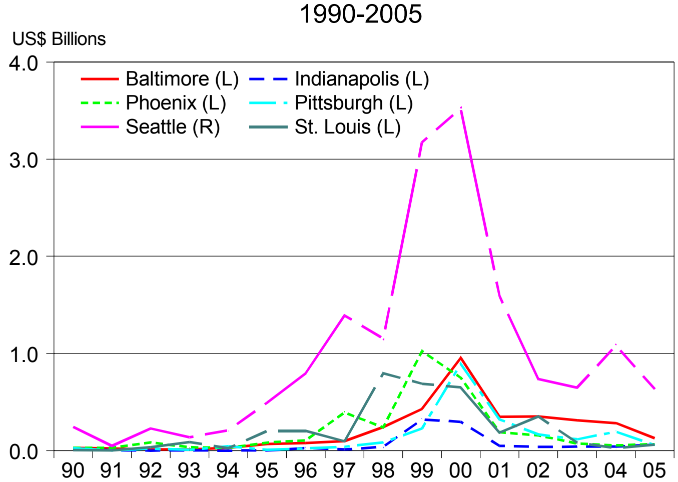


Source: Venture Economics

Looking at the sum of VC investment dollars per year (figure 15), Pittsburgh was one of the slowest to pick up the growth momentum of the IT boom. In 1999, its total VC investments ranked No. 6. At its peak, in 2000, Pittsburgh ranked second, after Baltimore, which had a consistently higher amount of VC investment dollars during the period.

In 2004, the sum of total VC investment dollars in Pittsburgh ranked No. 3. Although Pittsburgh's VC investment dollars were slower to gain *and* to lose momentum, it ranked fifth in 2005, with a sharp decline from its No. 3 position in 2004. This could be the result of risk adversity in its investment climate and/or a low concentration of high technology.

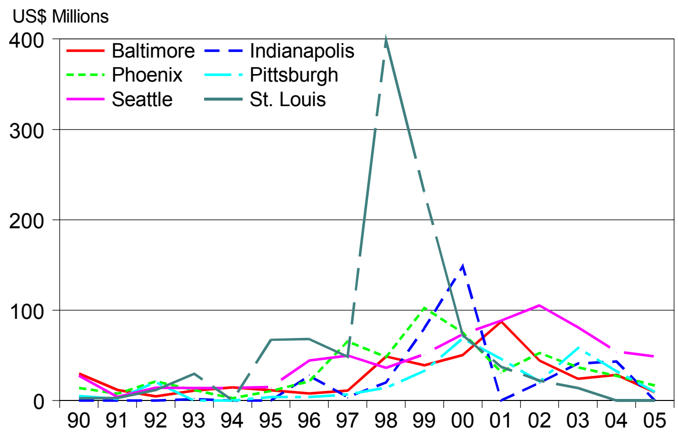
Figure 15: Sum of VC Investments
1990-2005



Source: Venture Economics

Taking a closer look at initial-stage deals (i.e., early stage, seed and startup venture capital), Pittsburgh's VC investment dollars were greatest in 2000 and 2003 (figure 16). In almost all years before 2000, Pittsburgh did not perform as well as the peer MSAs. After 2000, signs of growth emerged, but the decline afterward sent Pittsburgh far below Seattle. Still, in 2005 its performance in initial-stage deals was comparable to that of the other MSAs.

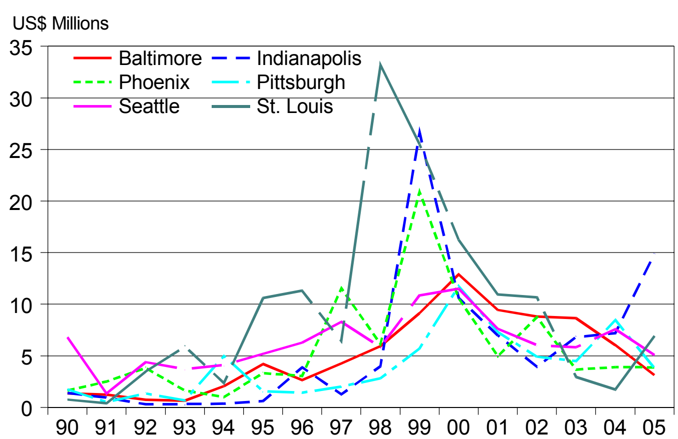
Figure 16: Avg. Invest. Dollars per Initial Stage Deal
1990-2005



Source: Venture Economics

Pittsburgh's average VC investment dollars showed a similar pattern as the sum of VC investment dollars for the same period (figure 17), with the exceptions of 1994 and 2004. This suggests outliers (anomalies) in those two years.

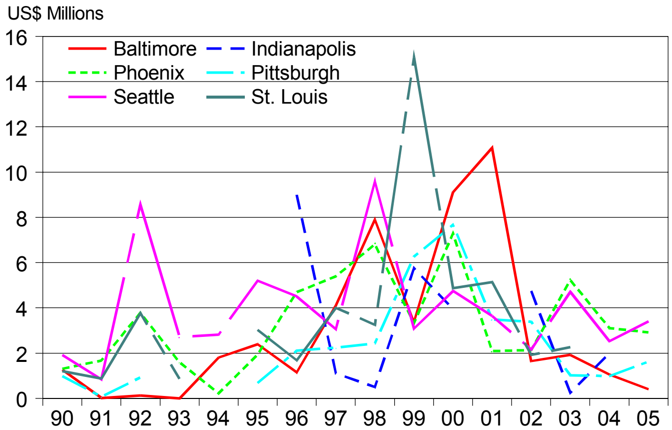
Figure 17: Average VC Investment Size per Year
1990-2005



Source: Venture Economics

Looking at early-stage VC investments, which include seed, startup and early stage investments (figure 18), Pittsburgh showed signs of growth toward 2000, but decline afterward, a trend found across the benchmarked MSAs. In 2003 and 2004, however, Pittsburgh's performance fell below that of most of the other MSAs. It picked up in 2005 but remained below Phoenix and Seattle. This suggests insufficient investment confidence in Pittsburgh.

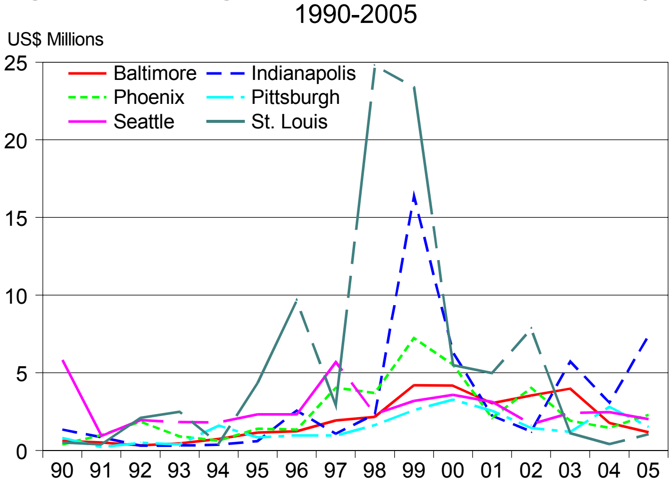
Figure 18: Avg. Invest. Dollars at Early Stages per Yr.
1990-2005



Source: Venture Economics

On average, VC investment per investor in Pittsburgh (figure 19) was lower than that for the other MSAs. This measure is a proxy to suggest the quality of VC investments in a region. A higher investment amount per investor suggests a higher quality of the deal. Trends in this measure for Pittsburgh were consistently low, again with the exception of 1994 and 2004 and their anomalies. Despite the IT boom in the late 1990s, increases in VC investment per investor were moderate, compared with increases in Indianapolis, Phoenix and St Louis. Baltimore's trends were similar to Pittsburgh's, but consistently higher. Again, exceptions occurred in 1994 and 2004. (Analysis of anchor firms and VC startups appears in later sections.)

Figure 19: Average VC Investment per Investor by Yr.
1990-2005



Source: Venture Economics

In 2004, NEP Broadcasting received a venture capital investment of $101 million ($30 million more than the next largest local VC investment that year). This single outlier pushed up the sum of VC investment dollars and average VC investment per investor. The investment qualifies as an outlier because NEP Broadcasting is in the communications industry, which does not show up as an industry strength in our examination of sectors.

2. Education Infrastructure

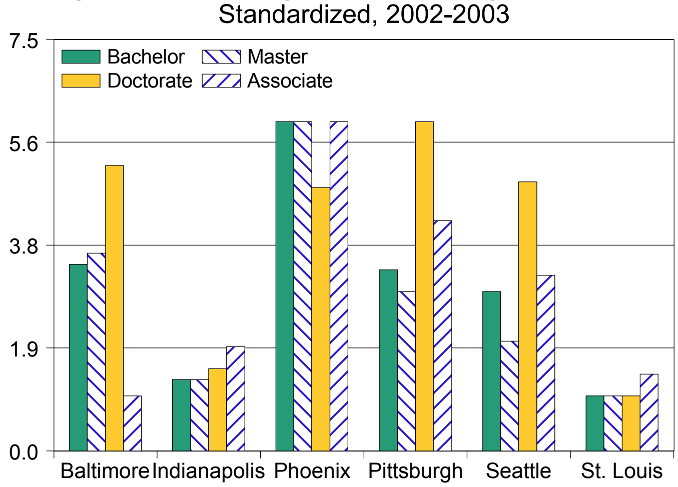
Education infrastructure refers to university-related attributes, which are the foundation for the development of the knowledge base built on human capital. As we found for the innovation pipeline, Pittsburgh also exhibits strengths in its education infrastructure. Table 8 summarizes strengths and weaknesses.

Table 8: Education Infrastructure – Strengths and Weaknesses Summary

	Strength	Moderate Strength	Moderate Weakness	Weakness
Sci/Engin BA degrees awarded		√		
Sci/Engin MA degrees awarded		√		
Sci/Engin Ph.D. degrees awarded	√			
Sci/Engin assoc degrees awarded	√			
National accreditation	√			
Full time instructional faculty		√		
Regional accreditation			√	
Faculty/Student ratio	√			√

Pittsburgh awarded high numbers of science and engineering degrees, and the most doctorates among the six MSAs for the 2002-2003 academic year (figure 20). The scores were standardized due to data limitations. We scored the MSAs on a scale of 1.0 to 6.0, whereby a higher score indicates higher awards of the respective degrees.

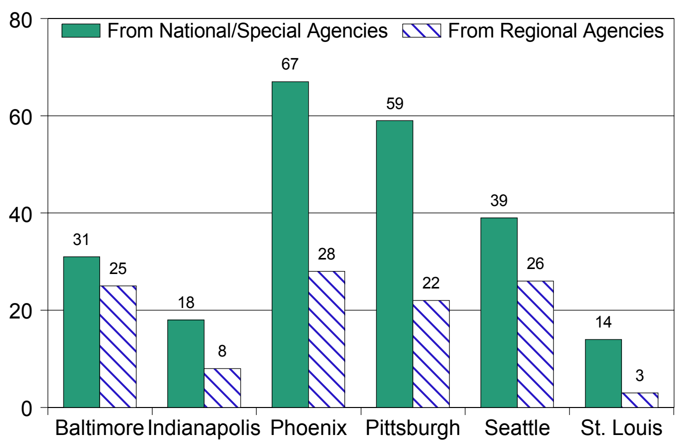
Figure 20: Sci./Eng. Associate Degrees Awarded
Standardized, 2002-2003



Source: NCES

Pittsburgh's universities enjoyed high recognition from national and special accreditation agencies (figure 21) in 2004. Yet while Pittsburgh has strength in national/special accreditations, in the same year its accreditations from regional agencies were moderately weak.

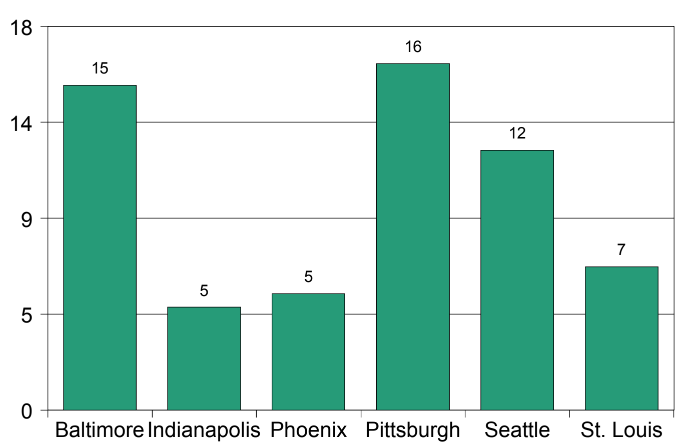
Figure 21: Number of Accreditations
2004



Source: NCES

Pittsburgh did have the highest number of faculty per 100 students in the group, yet the number of students enrolled for credit was comparatively low. One interpretation could be that Pittsburgh attracts solid numbers of full-time faculty members, but too few students. The situation was similar in Baltimore, which had 15 faculty members per 100 students but which also attracted more students. However, Pittsburgh's leading universities are research universities. Hence having a larger faculty-student ratio is advantageous to transferring the region's assets to a small group of high-quality students. Particularly, the University of Pittsburgh and Carnegie Mellon University are not inclined to expand their top departments so as to preserve the quality of their pedagogical practice.

Figure 22: Faculty per 100 Students
2003-2004



Source: NCES

3. Business Climate

In order to examine Pittsburgh's attractiveness as a destination for high-tech business, it is important to understand the region's basic business conditions. The following assessments apply to the general business climate but are useful when looking at the high-tech industry, as well.

Table 9: Business Climate – Strengths and Weaknesses Summary

	Strength	Moderate Strength	Moderate Weakness	Weakness
Cost of living	√			
Cost of doing business			√	
Personal income tax rate	√			
Corporate income tax rate				√
High-tech wage/High-tech worker 2004			√	
High-tech GDP				√
High-tech productivity			√	

In 2004, Pittsburgh had a lower cost of living than four of the other MSAs. Table 10 summarizes that year's cost of living and doing business. (The costs of living and doing business are measured relative to the national average; a score of 100 percent means the regional cost of living equals the national average.)

Table 10: Cost of Living and Cost of Doing Business by MSA

	Cost of Living		Cost of Doing Business	
MSA	Expressed as Percentage of U.S.	Standardized Score	Expressed as Percentage of U.S.	Standardized Score
Pittsburgh	86%	1.38	102%	4.44
Baltimore	105%	5.04	106%	5.69
Phoenix	102%	4.46	94%	1.94
Indianapolis	84%	1.00	93%	1.63
St. Louis	87%	1.58	91%	1.00
Seattle	110%	6.00	107%	6.00

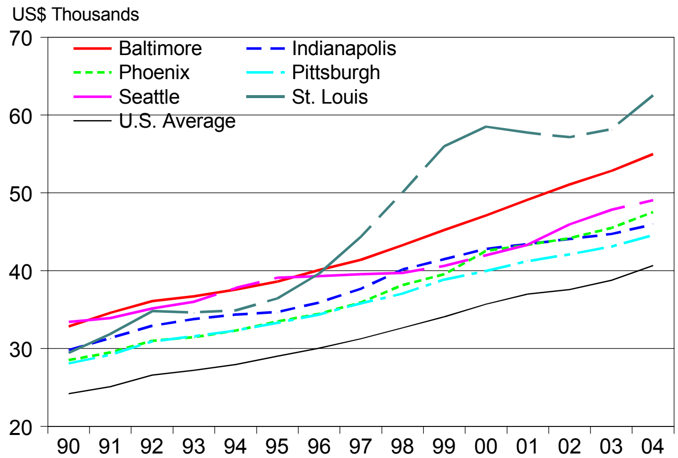
Source: Economy.com

Pittsburgh's cost of living was 14 percent below the national average in 2004. Given the area's cultural and natural assets, this was a bargain. Phoenix and Baltimore cost more than average, and Seattle was much more expensive. In the first quarter of 2005, the median price of a single-family home in Pittsburgh was about $106,000, far lower than the national average of $188,000, according to the National Association of Realtors. This constitutes a strength.

However, Pittsburgh showed a moderate weakness in the cost of doing business, which was 2 percent higher than the 2004 national average. And among the six MSAs, Pittsburgh showed the greatest difference between the cost of living and the cost of doing business. The low cost of living may not be a sufficiently motivating factor for industry development.

For all MSAs, the wages disbursed per worker from 1990 to 2004 (figure 23) were consistently higher than the national average.

Figure 23: Total Wages Disbursed per Worker
1990-2004

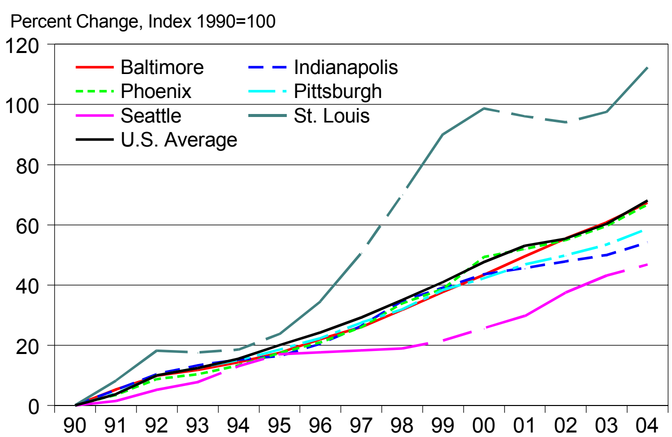


Sources: Milken Institute, Economy.com

However, with the exception of St. Louis, the increments in total wages per worker, indexed to 1990, varied. Indexed-growth charts demonstrate the annual growth relative to a single year of reference. Given that most data went back to 1990, we use that as the reference year. The 14-year period from 1990 to 2004 captures the upswings and downturns of the high-tech industry nationwide.

In 1994, the wage increment for Pittsburgh dropped below the average national increment, where it has remained. Baltimore and Phoenix picked up in 2002 to be on par with the national increment. However, Pittsburgh, Seattle and Indianapolis did not.

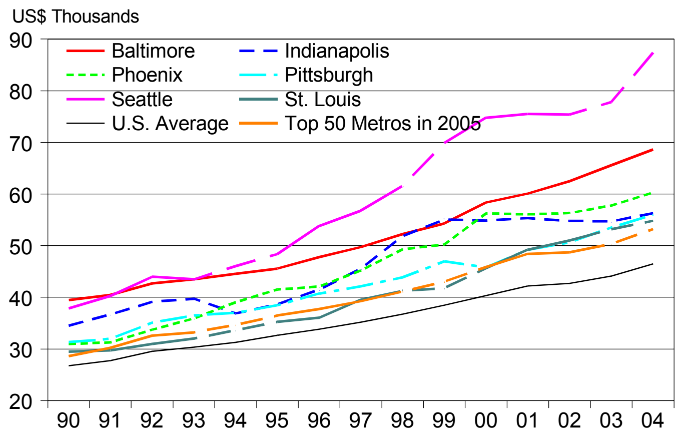
Figure 24: Total Wages per Worker Indexed Growth
1990-2004



Sources: Milken Institute, Economy.com

From 1990 to 2004, high-tech wages stood considerably and consistently better than the national average for all six MSAs (with the exception of St. Louis, which came close in 1992). Although Pittsburgh's disbursement of high-tech wages per high-tech worker is higher than the national average, and slightly higher than the average of the top 50 metros, it is lower than that in Baltimore, Indianapolis, Phoenix and Seattle. Between 1999 and 2000, when the IT boom peaked and declined, high-tech wages dropped slightly for Pittsburgh and Indianapolis. Given the relatively low high-tech wages in Pittsburgh, it will be a challenge to attract and retain talent, regardless of its exceptional knowledge base. Wages may also reflect the output quality of the industry. The area's low high-tech wages suggest the low-quality output, which leads to lower performance in industry.

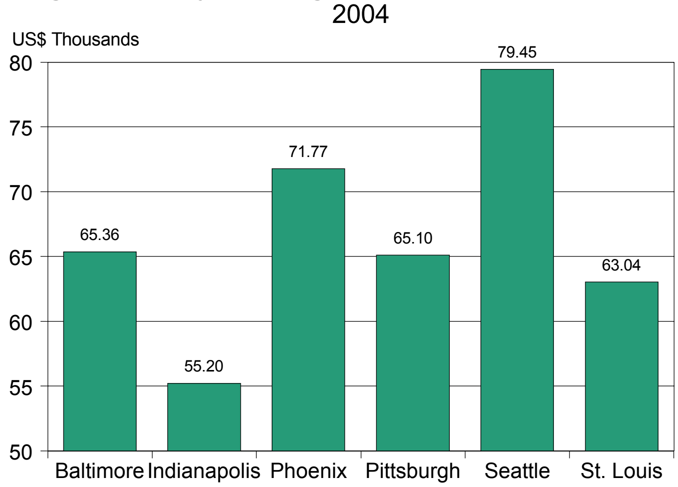
Figure 25: HT Wages Disbursed per HT Worker
1990-2004



Source: Economy.com

Adjusting for the cost of living, Pittsburgh's high-tech wages remained low (figure 26). Still, they appear comparable to nearby Baltimore and St. Louis, which are competitors despite their weaker R&D assets.

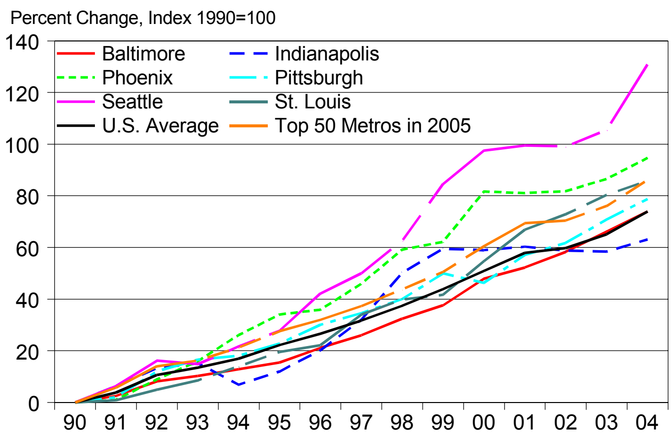
Figure 26: Adj. HT Wages Disbursed per HT Worker
2004



Sources: Milken Institute, Economy.com

Pittsburgh does show signs of growth (figure 27), albeit slow growth. Indexing the increase in high-tech wages to 1990, we see an overall positive and consistent trend (with the exception of 1999 to 2000, when wages dropped slightly below the national average). In 2002, the annual local increments rose above the national average again. Still, the figures suggest that while high-tech workers are becoming increasingly valued, local wages aren't sufficient to attract or keep them, given the rate of inflation. Note that although Pittsburgh's high-tech wages disbursed per high-tech worker are slightly higher than the average of the top 50 metros, its growth falls behind. This explains its relatively poorer performance as captured by the institute's best performing cities indexes.

Figure 27: HT Wages per HT Worker Indexed Growth
1990-2004



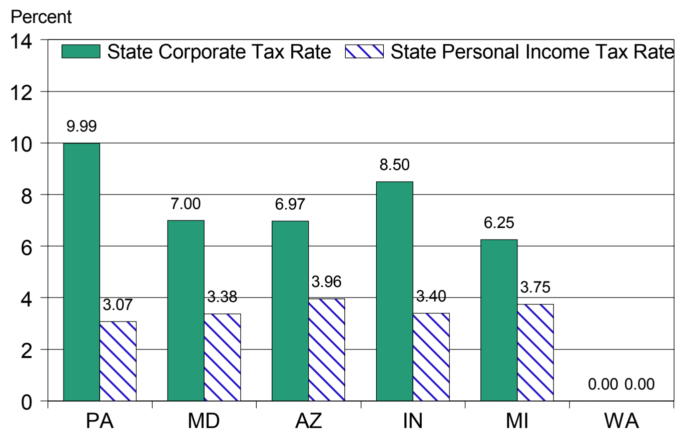
Source: Economy.com

In other industry jobs, Pittsburgh wages scored higher than the national average, but consistently below the other MSAs (see Appendix E). Indexed to 1990, wages are dropping for non-high-tech workers. Since 1993, the annual increments have shrunk and show no obvious signs of recovering. In 2004, Pittsburgh was among four MSAs whose non-tech industry annual wage disbursements increments stood below the national average.

Pittsburgh, Phoenix and St. Louis are all increasing their value placed on the high-tech industries. Baltimore, on the other hand, appears to be valuing its non-high-tech industries more than its high-tech industries (see Appendix E). It bodes well that Pittsburgh's indexed growth in high-tech wages is higher than both the national average and the wages disbursed to non-high-tech workers.

Although Pittsburgh had the lowest average personal state income tax rate of the MSAs last year, it also had the highest corporate tax rate, a discouraging sign for startups and spin-offs (figure 28). This may be detrimental to the development of anchor firms too.

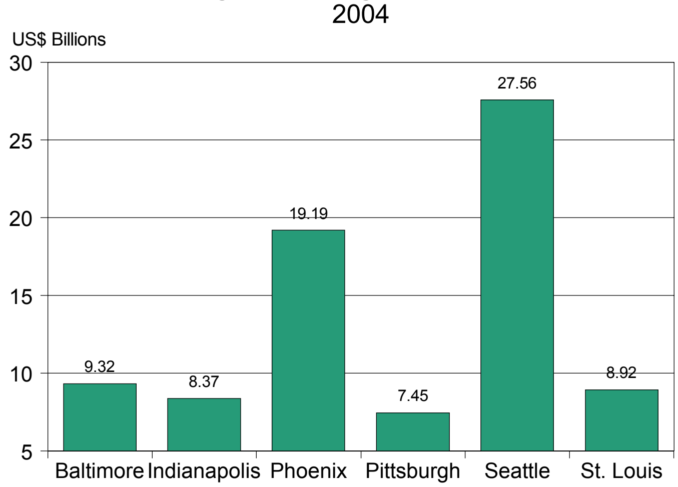
Figure 28: Corporate & Personal Income Tax Rates
2005



Source: Federation tax Administration

The rankings of the real GDP in high-tech sectors (Figure 29) show that Pittsburgh rated last among the six MSAs in 2004. We used nominal numbers for NAICS codes 3341, 3342 and 3344 in computing GDP, to account for the decline in prices for computer-related products. Given that the region ranked No. 4 in terms of high-tech productivity, there would seem to be a fairly low number of people working in the high-tech sector.

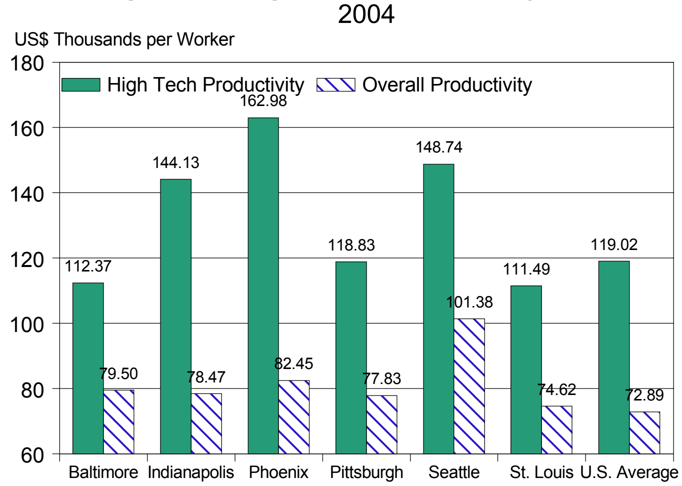
Figure 29: High-Tech GDP
2004



Sources: Milken Institute, Economy.com

Productivity was computed by dividing the total real high-tech GDP (with corresponding adjustments made to the three NAICS codes) by total high-tech employment. In 2004, Pittsburgh ranked second in tech sector productivity and fifth in terms of overall productivity. As with the other MSAs, Pittsburgh's high-tech sector was considerably more productive than its overall productivity, suggesting that the sector is a potential strength (figure 30). We provide a closer national comparison of tech productivity trends under Pittsburgh Industry Cuts.

Figure 30: High-Tech Productivity Levels
2004



Sources: Milken Institute, Eocnomy.com

Pittsburgh's low high-tech GDP and productivity fuels the low value of work in its high-tech industry. This is reflected in their low wage-income base. Without a competitive wage-income base, it is not surprising that Pittsburgh has a declining population since 1970 (see the section on Industry Concentration). It becomes critical therefore, to develop measures to attract and retain its human capital, which constitutes its most valuable asset for its high-tech industry.

Industry Analysis

1. Industry Development Capacity

Table 11 illustrates how regional conditions affect the growth of high-tech industries.

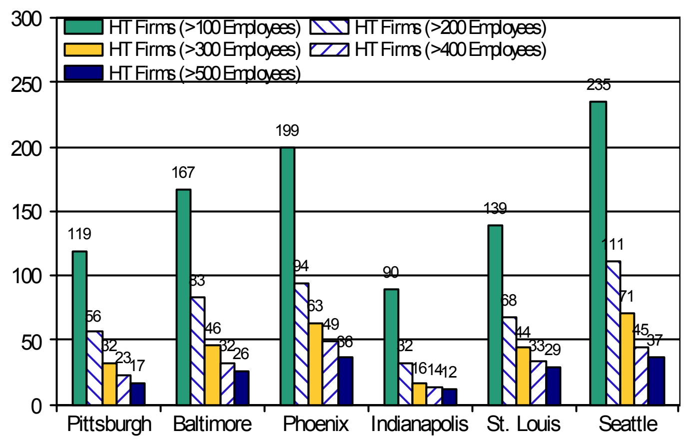
Table 11: Industry Development Capacity – Strengths and Weaknesses Summary

	Strength	Moderate Strength	Moderate Weakness	Weakness
University startups	√			
University R&D assets	√			
Corporate R&D assets		√		
High-tech anchors				√
High-tech establishments				√
Percentage of high-tech anchors				√
Entrepreneurial environment				√

Pittsburgh leads its peer MSAs in university startups and university R&D assets. However, to have a robust regional economy, private-sector growth needs to be more developed to absorb university startups and spawn corporate spin-offs.

Anchor firms, companies with 500 employees or more, play important roles in a region, sparking latent entrepreneurship and providing credibility and inspiration.[24] But in 2004, Pittsburgh showed a weakness in high-tech anchor firms. With only 17 anchor firms, it stood below all peer MSAs except Indianapolis.

Figure 31: High-Tech Firm Sizes
2004



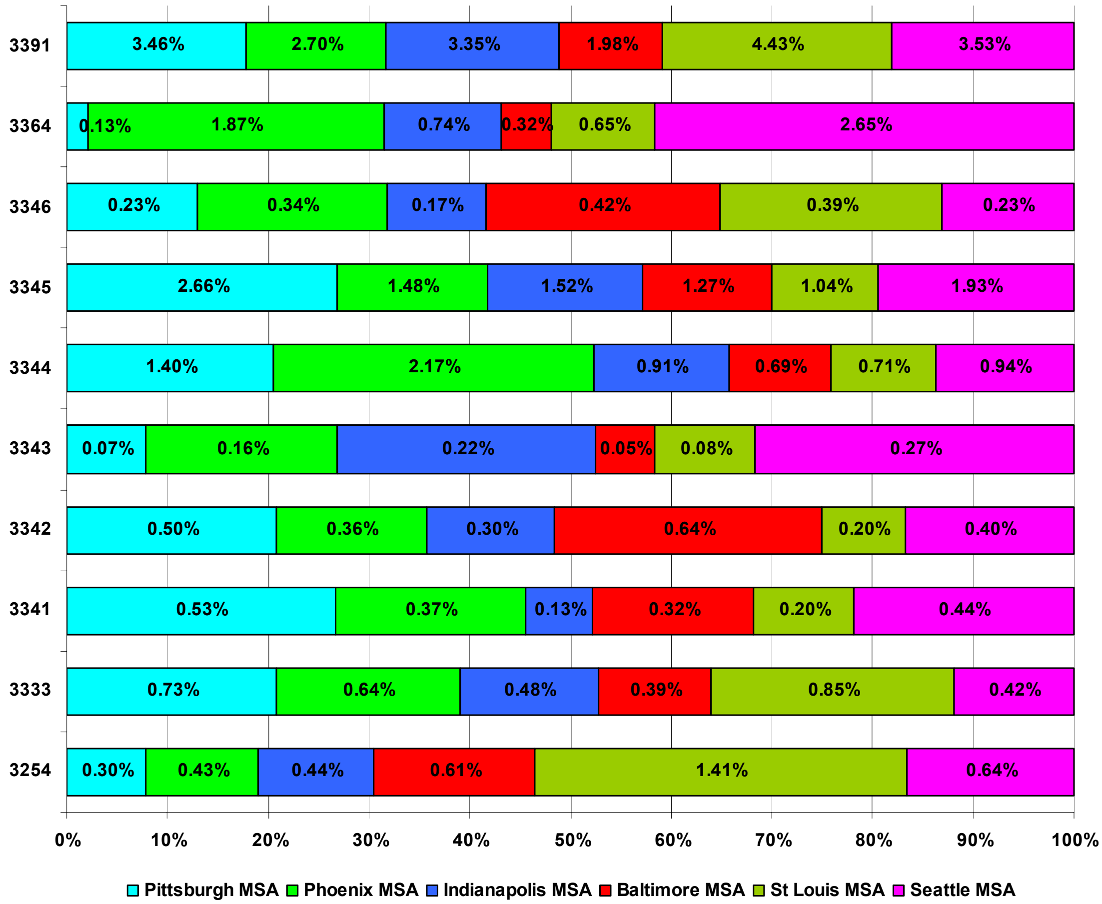
Source: Selectoryonline.com

Pittsburgh again showed a weakness in the number of smaller high-tech businesses in 2004. Looking at numbers of both small and anchor firms, we see that Seattle and Baltimore both scored very well, though most of their high-tech firms were not anchors. Phoenix, meanwhile, was home to both anchors and smaller firms. The results suggest that Pittsburgh currently lacks sufficient anchor and small firms to support a high-tech industry base, the driver of sustained economic growth.

Figures 32 and 33 compare the percentages of high-tech manufacturing and service firms in 2004. The bar for each NAICS code is broken up into colored segments, each representing one MSA. Each MSA segment includes its percentage of high-tech industries for that NAICS code and shows how it compares with the other cities. St. Louis, for example, had the greatest share of Medical Equipment and Supplies Manufacturing (NAICS code 3391), with 4.43 percent of its high-tech industries in that sector. The percentages show the portfolio composition for each MSA for each NAICS code.

In figure 32, Pittsburgh beats the other MSAs in its percentage of Computer and Peripheral Equipment Manufacturing (NAICS code 3341) and Nav/Measuring/Medical/Control Instruments Manufacturing firms (NAICS code 3345). Yet the number of these firms among all local high-tech firms stood at just 0.53 percent and 2.66 percent. Although Pittsburgh led other cities in these specific manufacturing areas, the local high-tech industry didn't reflect this.

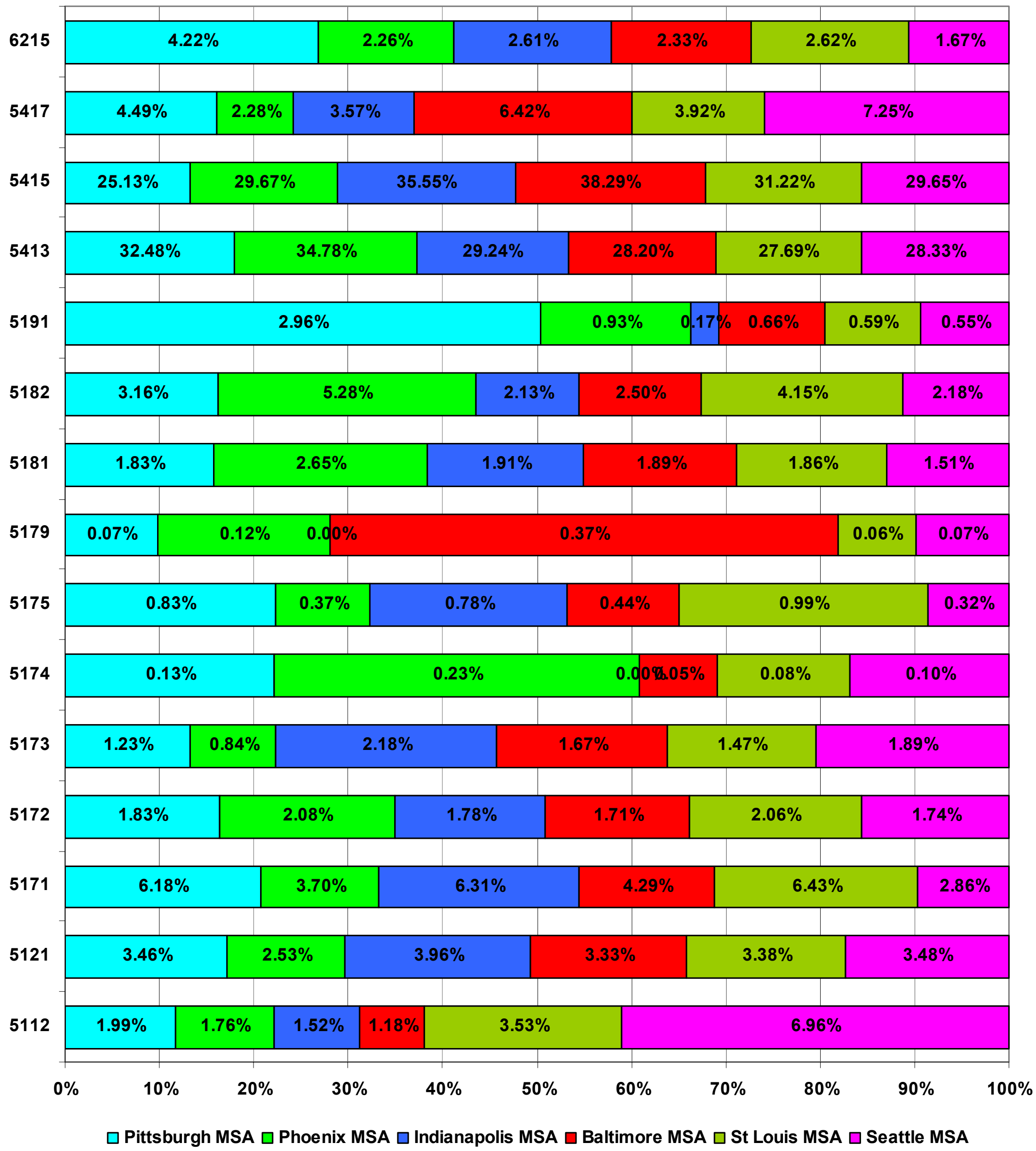
Figure 32: Percentage of High-Tech Manufacturing Firms, 2004



Source: Bureau of Labor Statistics

Pittsburgh also led (figure 33) in Other Information Services (NAICS code 5191) and Medical and Diagnostic Laboratories (NAICS code 6215). Other Information Services include news syndicates, libraries and archives, as well as various information services that cannot be classified under existing information services categories. Again, however, the percentages of local high-tech firms focused in this area were just 2.96 percent and 4.22 percent, respectively. On a positive note, Pittsburgh had a fairly high percentage of tech firms working in Architectural, Engineering and Related Services (NAICS code 5413) and Computer Systems Design and Related Services (NAICS code 5415). Nonetheless, Pittsburgh can do better, considering its strong engineering and computer science knowledge base.

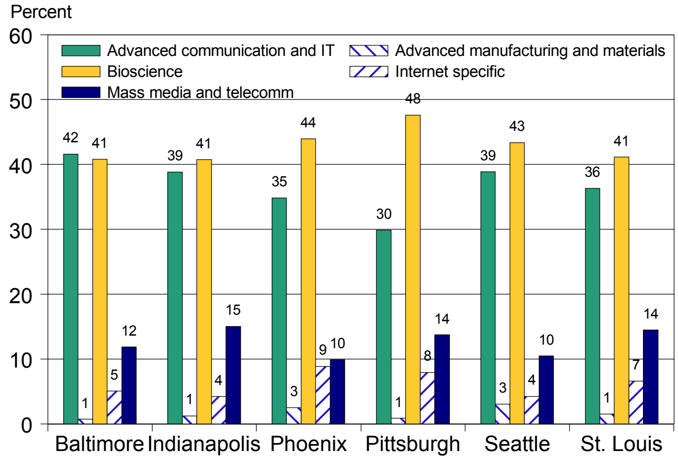
Figure 33: Percentage of High-Tech Services Firms, 2004



Source: Bureau of Labor Statistics

In figure 34, Pittsburgh shows its strength in bioscience firms, but a comparatively low percentage of advanced manufacturing and IT firms. With a heavier emphasis on biosciences, Pittsburgh may be able to leverage its concentration of bioscience firms. On the same note, the low concentration of advanced manufacturing and IT firms shows that Pittsburgh is not sufficiently leveraging its assets in science and technology.

Figure 34: Percentage of Clustered High-Tech Firms
2004

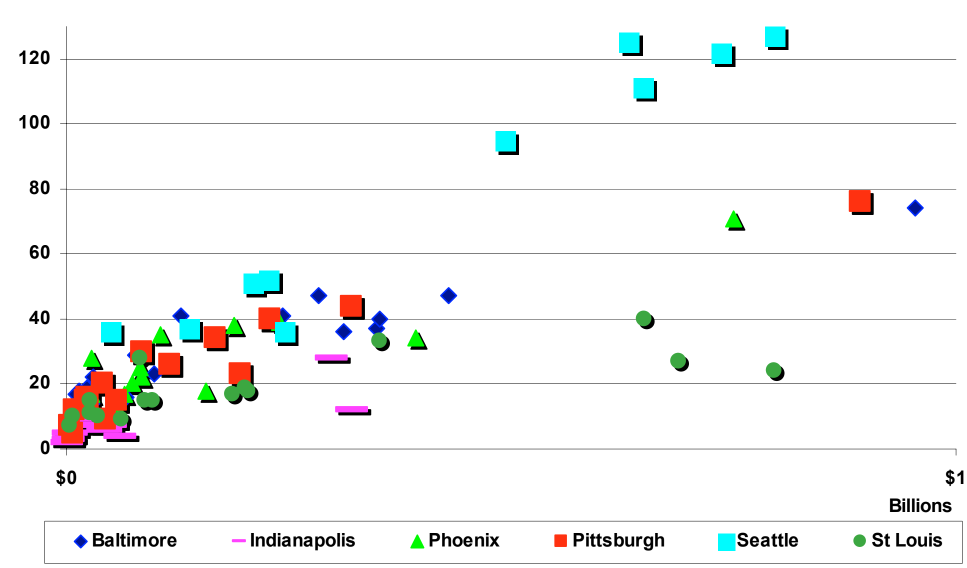


Source: Bureau of Labor Statistics

The capacity for development depends also on the environment for venture capital. As figure 35 shows, between 1990 and 2005 Pittsburgh's VC investment climate was comparable to that of the other MSAs, with the exception of Seattle. Indeed, Seattle scored far better on average than the remaining MSAs. (Seattle had six investment years, and Phoenix one investment year, in which some VC investments fell outside the range of the graph. These have been excluded to show more clearly the distribution of investment dollars and number of investments.)

This indicates a fairly optimistic situation for Pittsburgh. The sum of its VC investment dollars and number of its companies receiving VC investments are quite similar to figures for Baltimore, Indianapolis, Phoenix and St. Louis. We must note, however, that Pittsburgh experienced a single year (2004), in which investments were substantially larger.

Figure 35: Sum of Investment Dollars and No. of VC Investments Per Year 1990-2005

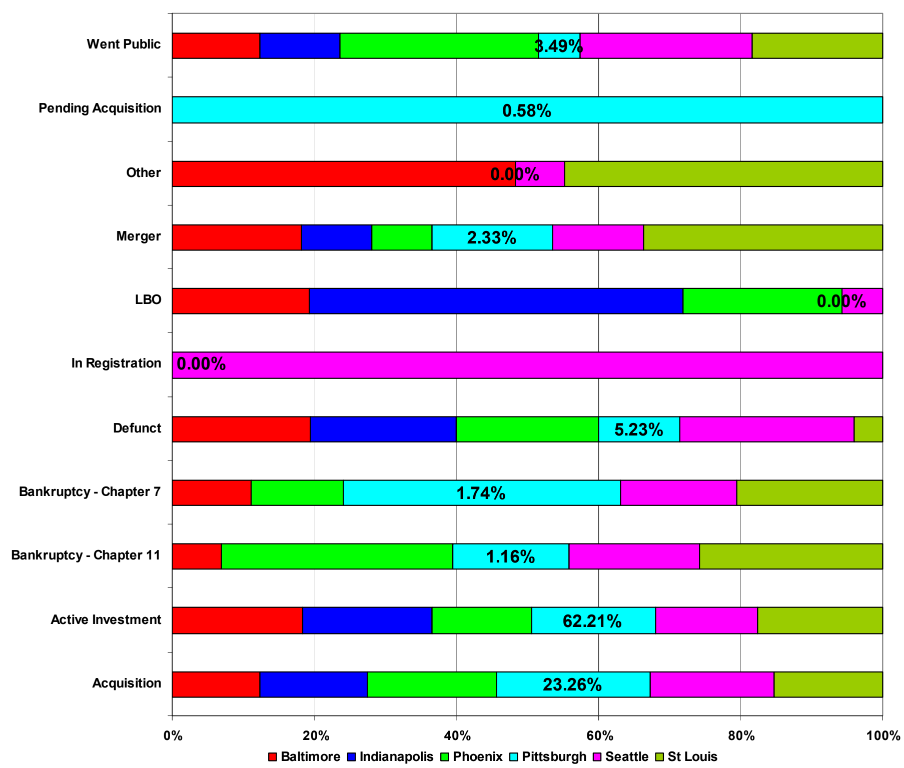


Source: Venture Economics

Figure 36 shows the breakdown of the current status of companies receiving VC support. The length of the colored bars reflects the breakdown of each status, such as going public, pending acquisition, etc., among the six MSAs. The percentages in the bars show the breakdown of companies in each status category within Pittsburgh. In Pittsburgh, 62 percent of companies that received VC funding are in "active investment," as shown in figure 36. Of the region's companies receiving VC investment, 23 percent have been acquired. These numbers, while positive, remain quite low compared to the totals in Seattle, which again scores better than the other five MSAs.

On the negative side, a high percentage of VC startups in Pittsburgh have filed for bankruptcy (both Chapters 7 and 11), in comparison to its peer MSAs. These percentages are far lower than Seattle's, but higher than Baltimore's. Companies receiving VC investments in Pittsburgh tend to have substantially short life cycles. While the absolute numbers are small, the numbers for the other MSAs are smaller.

Figure 36: Current Status of Companies Receiving VC Support



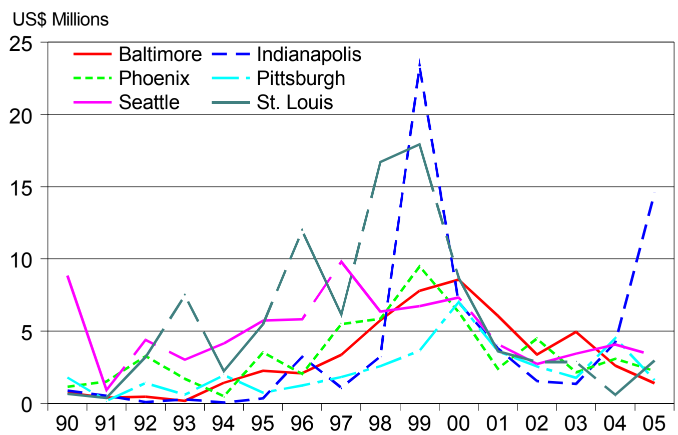
Source: Venture Economics

Venture capital can be an indicator for entrepreneurial environment.[25] By taking ratios of the sum of investment dollars to the sum of VC investment rounds per company, we can compute the potential for entrepreneurial activity. Figure 37 shows the trends of average VC investment per round from 1990 to 2005.

Pittsburgh's growth in VC investments per investment round fluctuates considerably. Similar to earlier findings, Pittsburgh's sum of VC investment dollars in 2004 was exceptional, resulting in a positive upturn for the year (and hence an anomaly). Overall, it seems that entrepreneurial environment based on VC investment per round in Pittsburgh is not stable. From figure 37, the momentum dropped in 2005. Baltimore, too, shows a slowdown in growth. Seattle and Phoenix were on the decline but now show signs of recovery. St. Louis has fallen since 1998 without recovery.

From figure 37, Pittsburgh's peak in 2000 was lower than that of the other MSAs, and its performance was optimistic only in 2004. Its average VC investment per round each year was lower than most of its peer MSAs despite its knowledge resources. Its companies are surviving, but an entrepreneurial climate does not exist that would enable them to grow. The mechanism to transform its resources to commercial value appears to be lacking.

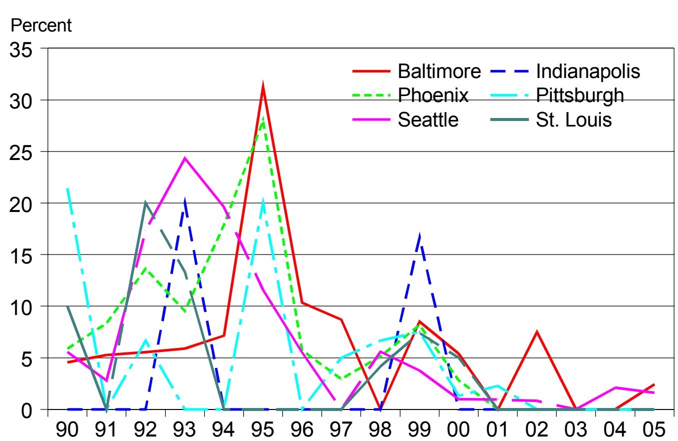
Figure 37: Avg. VC Investment per Investment Rnd
1990 to 2005



Source: Venture Economics

From 2000, all the MSAs scored low for the percentage of startups receiving VC support (figure 38). Only Baltimore and Seattle have enjoyed some recovery in subsequent years.

Figure 38: Percent. of Startups Receiving VC Dollars
1990-2005



Source: Venture Economics

2. Industry Concentration

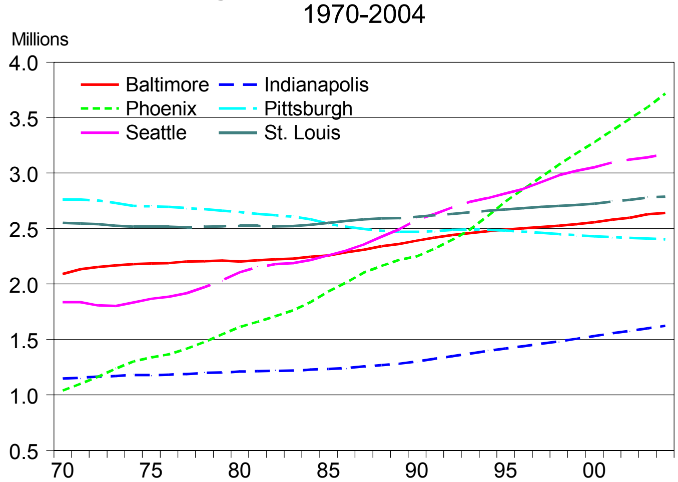
Industry concentration shows the makeup of the economy (table 12). In a knowledge-based economy, high-tech industries rely on human resources, which then become the fundamental basis for development.

Table 12: Industry Concentration – Strengths and Weaknesses Summary

	Strength	Moderate Strength	Moderate Weakness	Weakness
High-tech economic base				√
Net MSA migration				√
Median income of inward migrants				√
Median income of outward migrants				√

Pittsburgh shows its weakness in its high-tech economic base, as shown earlier in its innovation pipeline. From 1990 to 2004, its location quotient (relative to the U.S. location quotient) ranked last among the six MSAs, and it was the only region whose population continued to decline (figure 39). This weak demographic trend limited job growth and demand for housing and services, which in turn contributed to general economic slowdown and sluggishness in high-tech industry growth.[26]

Figure 39: MSA Population
1970-2004

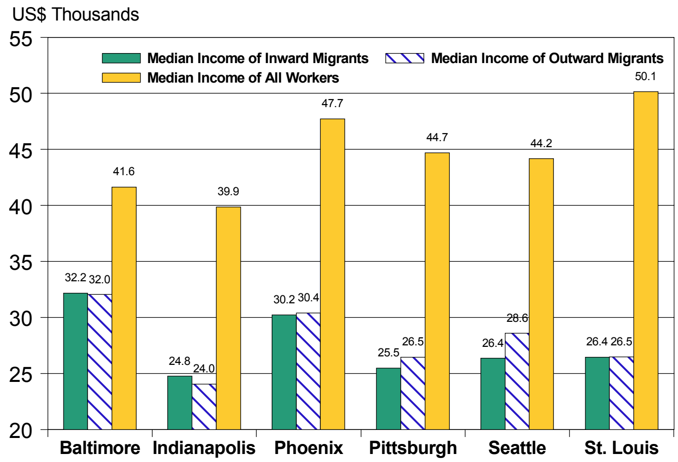


Source: Economy.com

If we compare adjusted income levels between those moving away from Pittsburgh and those moving to the region (figure 40), we see that between 1993 and 2004, the median income of those leaving Pittsburgh was higher than that of those arriving. Pittsburgh and Seattle are the only two MSAs with a lower median income of inward than outward migrants. Note that the median income of *inward* migrants of Seattle is similar to the median income of *outward* migrants from Pittsburgh. Coupled with low high-tech GDP and productivity, this migration fuels a downward spiral which inhibits the region in leveraging its human capital assets for long-term growth.

To adjust for the different costs of living in different MSAs, median income values were divided by the cost of living percentage. Pittsburgh and Seattle are the only two MSAs with a lower average median income of inward migrants compared to outward migrants. The low income reflects the lower value of production by the inward migrants to Pittsburgh.

Figure 40: Adj. Income of Inward / Outward Migrants
2004

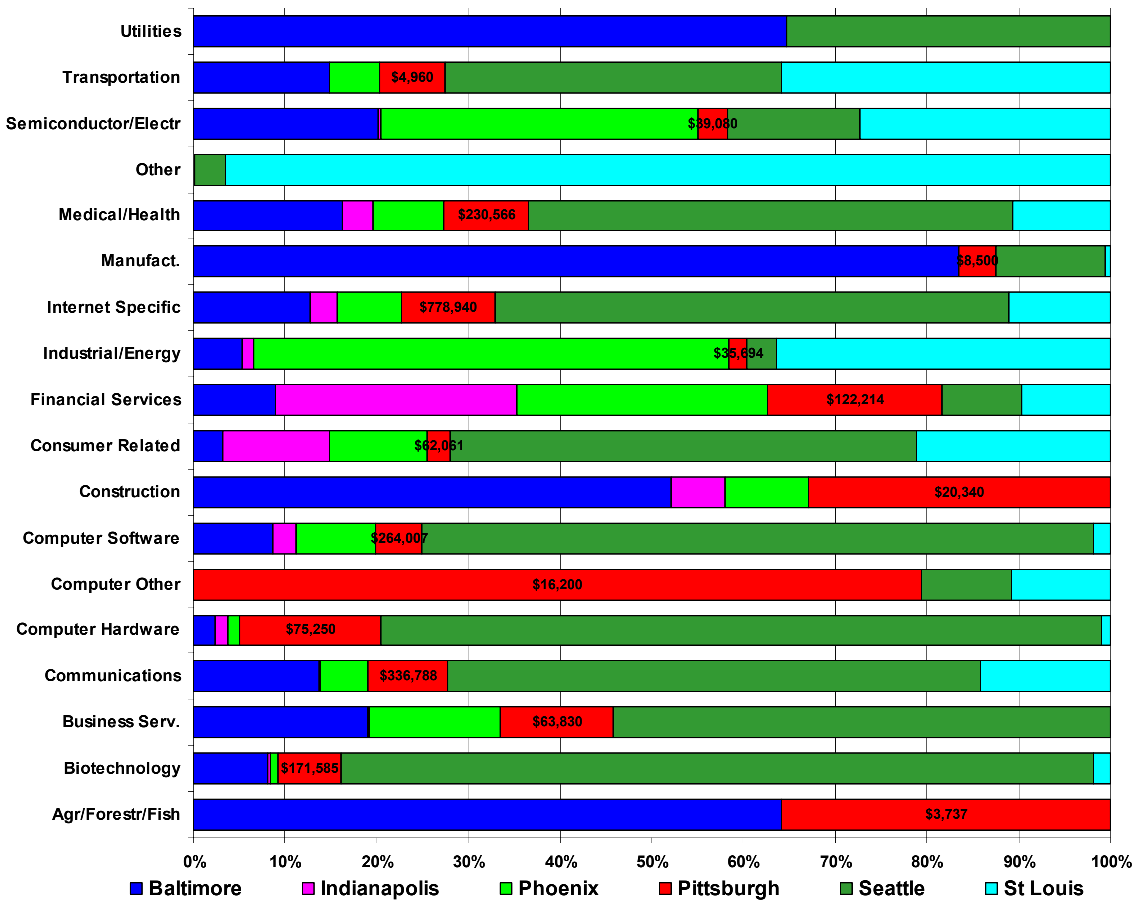


Source:Economy.com

The following chart (figure 41) shows Pittsburgh's VC investment portfolio broken down by industry subgroups. The length of the bars reflects percentage share of VC investment dollars in comparison with other benchmarked MSAs in each subgroup — utilities, transportation, etc. The number in the bars shows the VC investment dollars in Pittsburgh from 1990 to 2005. From the chart, Pittsburgh leads its peer MSAs in investments in the "computer/other" subgroup. Yet this amounts to just $16 million. Meanwhile, the $264 million Pittsburgh received in the "computer and software" subgroup leaves it no stronger than fourth among MSAs.

Given its strong knowledge base in computer science, Pittsburgh should theoretically draw a higher amount of VC investments in this area. Pittsburgh's VC investment portfolio shows that money is invested in areas where the benchmarked MSAs are not focusing their efforts on. Consider Internet-specific investments, whereby Pittsburgh's VCs showed an investment of more than $778 million. However, this was less than one third of Seattle's investment in this area. The same applies to medical and health investments.

Figure 41: Percentage of Total VC Investment Dollars by Industry Sub-Group 1990-2005
US$Thousands, 1990-2005



Source: Venture Economics

3. Industry Productivity

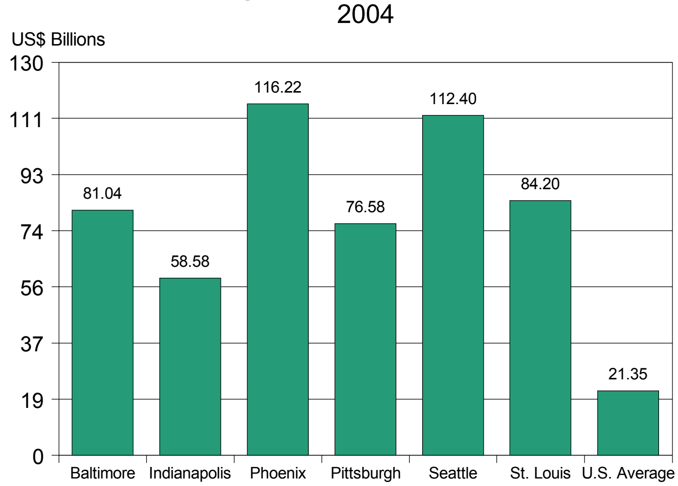
The output of a high-tech economy shows how much it produces. And the value of this production is reflected in the wages disbursed. In addition, the ratio of output to input illustrates how productive the economy is. We use industry GDP as the output measure, and employment as the input measure. We use real GDP for all industry cuts, and adjusted GDP for NAICS codes 3341, 3342 and 3344. Given the industry reliance on human capital, we use high-tech employment as the input measure.

Table 13: Industry Productivity – Strengths and Weaknesses Summary

	Strength	Moderate Strength	Moderate Weakness	Weakness
Overall GDP				√
High-tech GDP				√
GDP contribution from high-tech				√
Overall productivity		√		
High-tech productivity			√	

The overall GDPs of the MSAs in 2004 are given in figure 42. Pittsburgh had a weakness in this measure, despite the sharp increase in VC investments for the year. The region rated far below Phoenix and Seattle, whose GDPs totaled more than $110 billion. Baltimore again draws very close to Pittsburgh in overall GDP.

Figure 42: Overall GDP
2004



Sources: Milken Institute, Economy.com

Looking at national rankings (table 14), Pittsburgh rated a strong 27th among 379 MSAs. Still, it held the next-to-last position among the benchmarked MSAs.

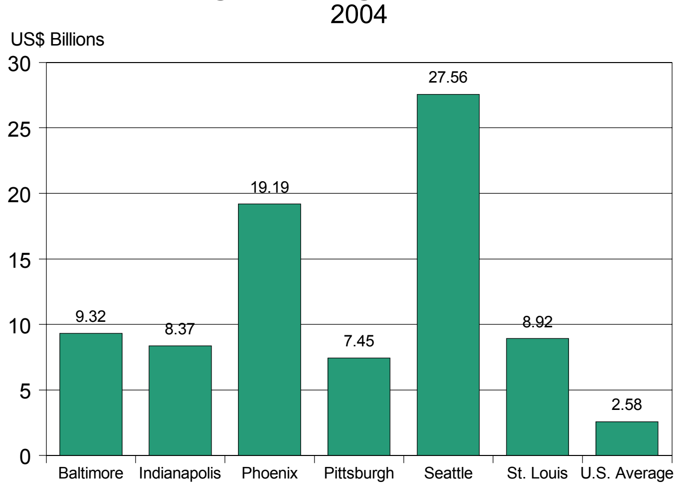
Table 14: National Rankings of Overall GDP, 2004

	Overall GDP ($Millions)	Ranks 2004
Phoenix	116,221.18	11
Seattle	112,395.33	12
St Louis	84,196.53	23
Baltimore	81,043.42	25
Pittsburgh	76,579.88	27
Indianapolis	58,584.04	39

Source: Economy.com

Despite its VC investment dollars, knowledge assets and high overall GDP, Pittsburgh's high-tech GDP also scored low, last among the six MSAs (figure 43). This again suggests that the region is not fully leveraging its knowledge assets and that the local economy is not sufficiently driven by its high-tech industry. The effects of VC investments in 2004, however, remain to be seen.

Figure 43: High-Tech GDP
2004



Sources: Milken Institute, Economy.com

Though it rates above the national average of $3 billion, Pittsburgh's $7 billion high-tech GDP is not a promising number, despite its position at 33rd.

Table 15: National Rankings of High Tech GDP, 2004

MSA	High-Tech GDP 2004 ($Millions)	Rank
Seattle	$27,558.90	5
Phoenix	$19,187.70	13
Baltimore	$9,321.03	25
St. Louis	$8,923.49	27
Indianapolis	$8,368.18	30
Pittsburgh	$7,450.85	33

Source: Economy.com

Productivity values were computed by dividing GDP by the number of workers for the same period. Table 16 and figure 44 illustrate overall productivity levels. Pittsburgh's overall productivity is only $5,000 above the U.S. average. Looking at national rankings, Pittsburgh occupies 124th place. Still, among the peer MSAs, only Seattle made the top 100.

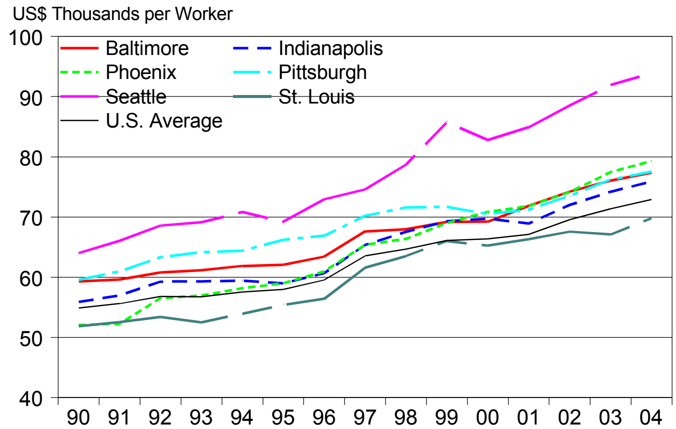
Table 16: National Rankings of Overall Productivity, 2004

	Overall Productivity ($Thousands per worker)	Ranks 2004
Seattle	93.88	26
Phoenix	79.31	109
Pittsburgh	77.54	124
Baltimore	77.37	128
Indianapolis	75.89	146
St. Louis	69.78	209

Source: Economy.com

Pittsburgh did perform considerably and consistently better than the national average from 1990 to 2004, in terms of its overall productivity.

Figure 44: Overall Productivity
1990 to 2004



Source: Economy.com

In overall economy, Pittsburgh still faces a big threat from a population downturn. Given its relatively high overall GDP and low productivity, the metropolitan area appears to have a comparatively high number of employees who add little value to the high-tech industry. Thus, as employee numbers decline, the quantity or value of output may be reduced even more.

At this point, we turn to the high-tech industries (see again, figure 30). In Phoenix, the high-tech industry is substantially driving its economy because of its greater productivity. In Pittsburgh, as well, high-tech productivity surpasses overall productivity. Just the same, its high-tech productivity is comparable to the national average of $119 per worker.

Nor does Pittsburgh's high-tech productivity rank within the top 100 MSAs (table 17). At just $119,000, it ranks lower than national overall productivity but still surpasses Baltimore on both measures. Phoenix tops the high-tech productivity rankings. Given that Pittsburgh's high-tech GDP is substantially higher than its overall GDP, its high-tech industry is clearly driving its economy. However, the comparatively low high-tech GDP is a cause for concern for the region. This goes beyond its high-tech industry and applies to its overall economy.

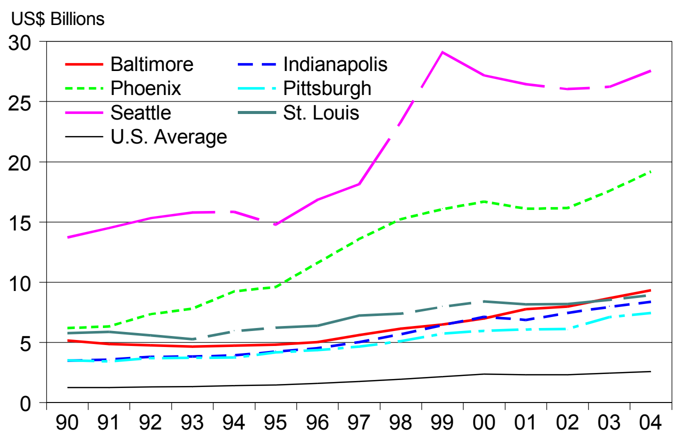
Table 17: National Rankings of High-Tech Productivity, 2004

	High-Tech Productivity ($Thousands per high-tech worker)	Ranks 2004
Phoenix	$163.00	41
Seattle	$148.75	74
Indianapolis	$144.16	81
Pittsburgh	$118.84	174
Baltimore	$112.39	199
St Louis	$111.48	202

Source: Economy.com

Pittsburgh's high-tech GDP remained consistently low from 1990 to 2004 (Figure 45). In fact, it ranked last among the MSAs throughout the period, exhibiting few signs of growth during the IT boom. On the other hand, it did not show signs of sharp decline after the IT crash in 2000.

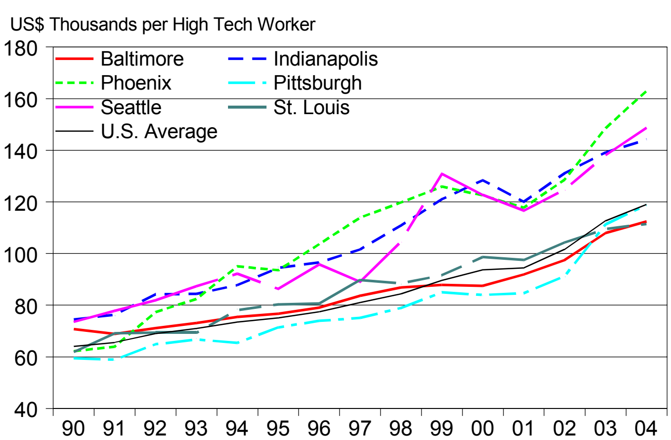
Figure 45: High-Tech GDP
1990-2004



Source: Economy.com

Pittsburgh's high-tech productivity also ranked consistently last until 2003, when it moved up to fourth (figure 46). The region still has substantial room for high-tech growth if it can attract more high-tech workers. Worker retention and the reversal of outward migration are of paramount importance.

Figure 46: High-Tech Productivity
1990-2004



Source: Economy.com

From 1999 to 2001, growth in local high-tech productivity stagnated but remained relatively unharmed by the IT crash. However, that productivity remains far below productivity in Phoenix, Indianapolis and Seattle. And while Pittsburgh's productivity picked up sharply in 2002, it still could not match the top three MSAs.

In sum, Pittsburgh's high-tech industry is a key driver of its economy because of the high GDP from its high-tech industry compared to its overall GDP. However, its low high-tech productivity suggests that the industry does not produce high-value, high-tech products and services comparatively. This is reflected in its comparatively low high-tech wages. Without a vibrant industry base that produces high-value products and services, wages will be low. Hence, it becomes difficult to attract and retain quality talent, even those produced by Pittsburgh's renowned institutions.

Pittsburgh Industry Cuts

Looking at individual industry sectors, Pittsburgh is strong in two manufacturing sectors, "manufacturing and reproducing optical media" and "communications equipment manufacturing." Among high-tech services sectors, Pittsburgh showed no signs of a clear leadership among its peer MSAs.

The next two charts summarize manufacturing and service industry cuts in 2004. The two axes depict standardized scores of the number of establishments and the employment numbers for each of the 25 industry categories. The scores were computed by standardizing and comparing the number of establishments and employment numbers for the six MSAs. This method accounts for ordinal differences, as well as the magnitude of the differences.

The scores for employment and establishments were obtained by ranking the absolute numbers of each attribute against the five peer MSAs. The magnitude of differences in ranks were taken into consideration and mapped into a scale of 1 to 6. The resulting scores were then used to plot the following two scatter grams to illustrate Pittsburgh's strengths, weaknesses, opportunities and threats in its high-tech industry sectors.

Definitions

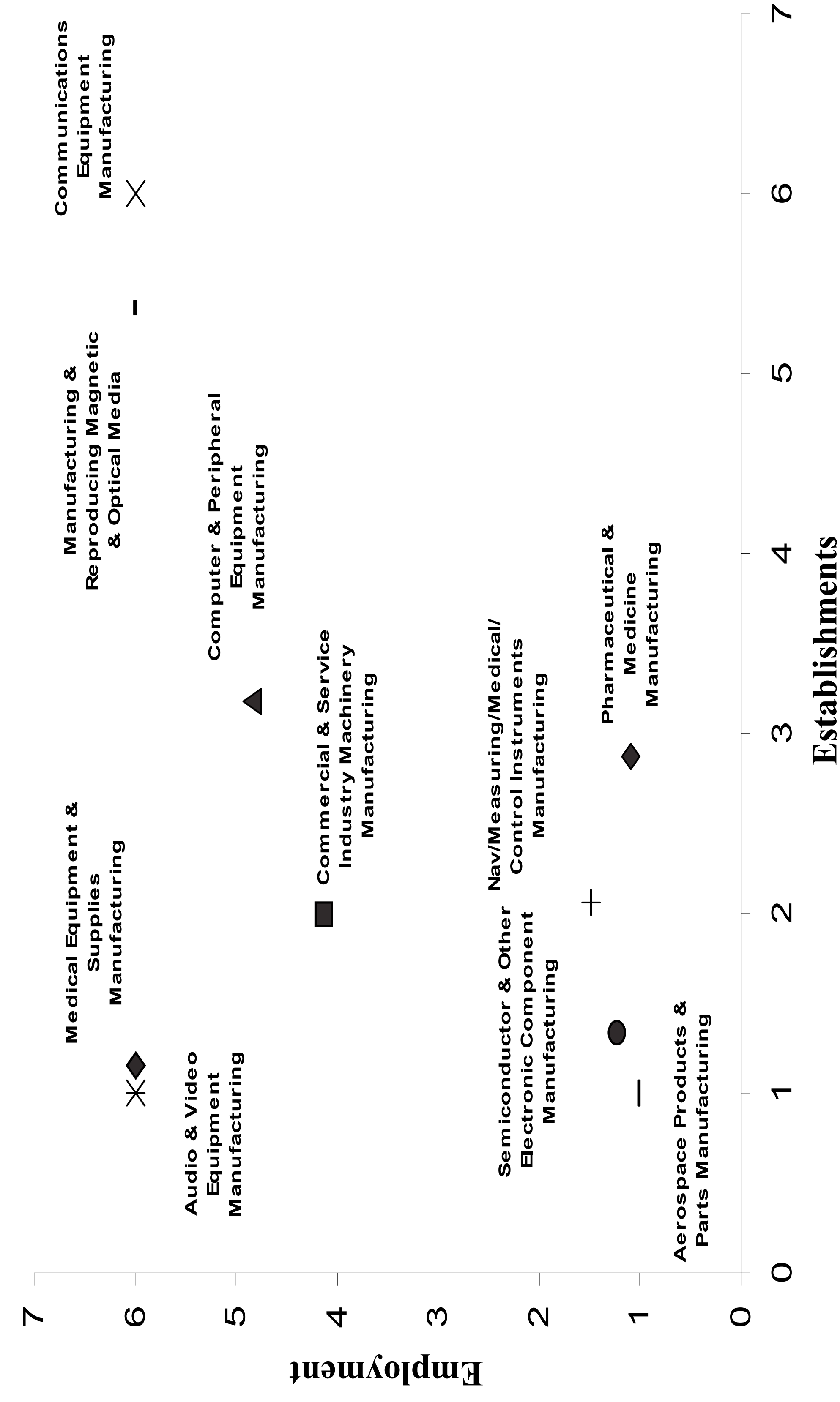
A **strength** is defined as a sector that scores > = 4.5 in both number of establishments and employment.

A **weakness** is defined as a sector that scores < = 2.5 in both number of establishments and employment.

An **opportunity** is defined as a sector that has a score of > = 4.5 in one of the two axes and a moderate score (2.5 < = x < = 4.5) in the other. Boosting the **moderate scores**, Pittsburgh could potentially gain another strength.

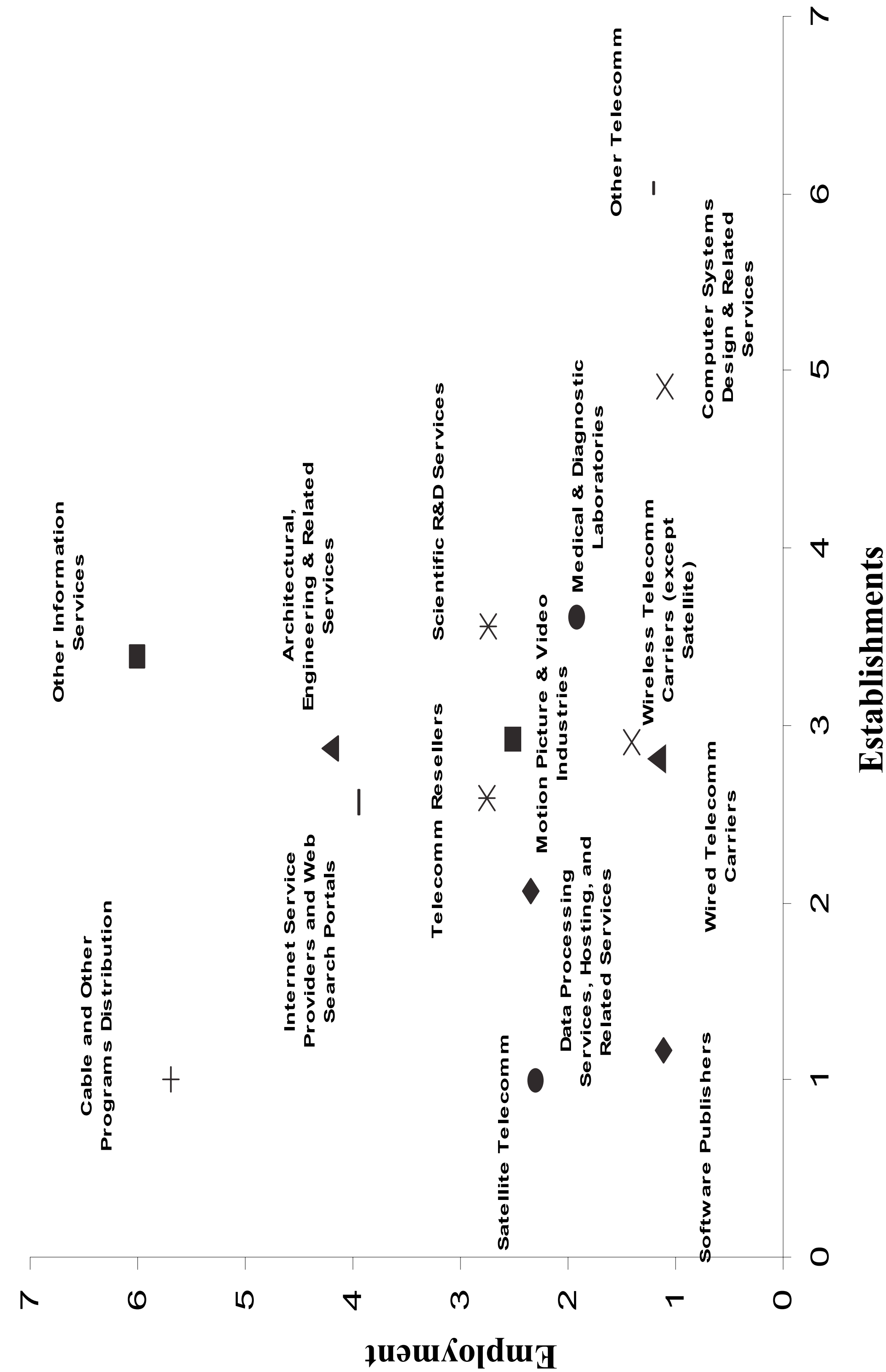
A **threat** is defined as a sector with a score of > = 2.5 in one of the two axes and < = 5 in the other. The low-ranking axis may result in the loss of the strength in the corresponding axis without intervention.

Figure 47: Pittsburgh Benchmarked High-Tech Manufacturing (Standardized)



Source: Economy.com, Bureau of Labor Statistics

Figure 48: Pittsburgh Benchmarked High-Tech Services (Standardized)



A summary of the strengths, weaknesses, opportunities and threats is given in table 18. These sectors deserve special attention. Four sectors were added to the advanced manufacturing and materials cluster for more in-depth analysis. These four additional sectors—"basic chemical manufacturing," "resin, synthetic rubber and artificial synthetic fibers and filaments manufacturing," "paint, coating, and adhesive manufacturing," and "other chemical product and preparation manufacturing"—are not classified under the Milken Institute's high-tech definition.

Pittsburgh's strong clusters are its bioscience and internet-specific clusters, with location quotients around 1.0. However, only 7.95 percent of its high-tech firms are in the internet-specific cluster. Its firm location quotients for the bioscience and internet-specific clusters are 0.57 and 0.78 respectively, a marked difference from its employment location quotients.

Although the region's advanced communication and IT cluster showed low location quotients by employment and firms, "communications equipment manufacturing" showed up as a strength in the region, with an employment location of 1.25. However, its location quotient by firms was only 0.12. This means the sector is dominated by a small number of companies. Looking at other location quotients by firms for the region, Pittsburgh's high-tech clusters do not seem to have a large firm base to match the high-tech employment in the region. A closer look at the individual industry sectors is given in the subsequent section.

Table 18: Pittsburgh Industry Cuts SWOT Summary

NAICS	Cluster	Industry 2004	SWOT	Emp LQ	Cluster Emp LQ	Firm LQ	Cluster Firm LQ
3341	Advanced Communication and IT	Computer and peripheral equipment manufacturing	O	0.46	0.37	0.13	0.54
3342		Communications equipment manufacturing	S	1.25		0.12	
3343		Audio and video equipment manufacturing	T	4.27		0.15	
3344		Semi-conductor and other electronic component	W	0.46		0.17	
3346		Manufacturing and reproducing magnetic and optical media	S	1.5		0.26	
5112		Software publishers	W	0.49		0.33	
5415		Computer systems design and related services	T	0.66		0.80	
3333	Advanced Manufacturing and Materials	Commercial and service industry machinery manufacturing	W	1.17	0.70	0.28	0.48
3364		Aerospace products and parts manufacturing		0.04		0.01	
3351*		Basic chemical manufacturing		0.83		0.35	
3352*		Resin, synthetic rubber & artificial synthetic fibers & filaments mfg		2.09		0.23	
3355*		Paint, coating, & adhesive manufacturing		1.99		0.41	
3359*		Other chemical product & preparation manufacturing		1.10		0.59	
3254	Bioscience	Pharmaceutical and medicine manufacturing		0.45	1.01	0.04	0.57
3345		Nav/measuring/medical/control instruments manufacturing	W	0.54		0.22	
3391		Medical equipment and supplies manufacturing	T	1.53		0.50	
5413		Architectural, engineering and related services		1.2		0.87	
5417		Scientific r&d services		0.89		0.29	
6215		Medical and diagnostic laboratories		1.23		0.81	
5181	Internet-Specific	Internet service providers and web search portals		0.93	0.99	0.78	0.78
5182		Data processing services, hosting, and related services	W	0.76		0.47	
5191		Other information services	O	2.63		2.54	
5121	Mass Media and Telecommunications	Motion picture and video industries		0.45	0.79	0.66	0.43
5171		Wired telecomm carriers		0.95		0.39	
5172		Wireless telecomm carriers (except satellite)		0.93		0.36	
5173		Telecomm resellers		0.51		0.41	
5174		Satellite telecom	W	0.23		0.47	
5175		Cable and other programs distribution	T	1.76		0.35	
5179		Other telecomm	T	0.37		0.86	

Source: Milken Institute, Economy.com, Bureau of Labor Statistics

*Additional industries not classified under the Milken Institute's high-tech definition

On the manufacturing side, Pittsburgh has strengths in both "communications and equipment manufacturing," and "manufacturing and reproducing magnetic and optical media." "Aerospace products and parts manufacturing," "nav/measuring/medical/control instruments manufacturing" and "semiconductor and other electronic component manufacturing" show up as weaknesses.

"Audio and video equipment manufacturing" constitutes a sector threat. While the sector is very strong in terms of employment, its number of establishments is very low. Sony and Robicon are the only two firms in this sector with a presence. The same can be said of "medical equipment and supplies manufacturing." Cook Vascular Inc. alone accounts for 1,790 employees. The dominating presence of these large establishments is advantageous, in terms of sales and employment, and as potential anchor firms that could bring in subsidiary companies. But the corresponding low number of total establishments in this industry shows a vulnerability considering the strong dependency on these few establishments.

"Computer and peripheral equipment manufacturing" shows up as an opportunity, but not a clear opportunity because of its moderately high employment numbers.

On the services side, Pittsburgh shows no strengths in any sector. The "software publishers," "satellite telecom" and "data processing services, hosting and related services" sectors show up as weaknesses. This finding appears to reinforce the argument that Pittsburgh is lacking the infrastructure to commercialize university R&D.

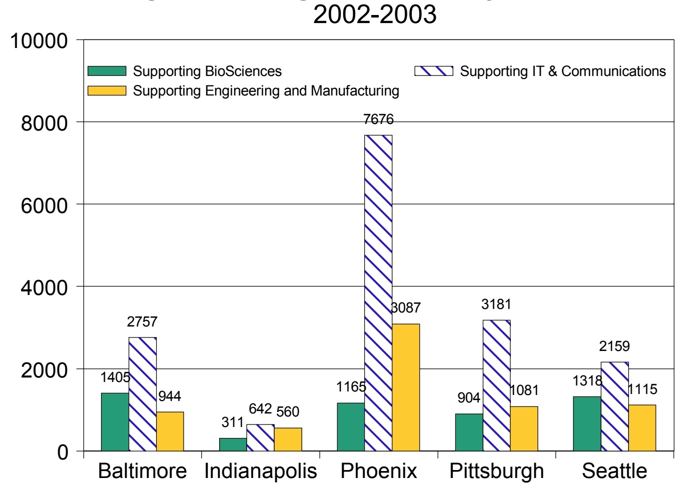
Three sectors amount to threats: "cable and other programs distribution," "computer systems design and related services," and "other telecomm." In "computer systems design and related services," iGate Corp. accounts for 500 employees. Multiple companies in the other two sectors employ very few workers.

On a positive note, "other information services" is a sector on which Pittsburgh can capitalize. Sector examples include news syndication (NAICS code 51911) and library archives (NAICS code 51912). Currently, the sector has high employment, but only a moderate number of establishments.

Pittsburgh can exploit its sector "opportunities" by encouraging greater expansion and development to utilize the high numbers of people trained in these fields. Figure 49 illustrates the distribution of degrees awarded by discipline. The primary degree disciplines were aggregated to show their direct support for the five clusters used in our analysis.

Degrees awarded in biosciences support the bioscience cluster, those awarded in information technology and communications support the advanced communication and IT, telecommunications, and internet-specific clusters, and finally, degrees awarded in engineering and manufacturing disciplines support the advanced manufacturing and materials cluster. It must be noted that a direct match is difficult to obtain, because degree awards are not organized by NAICS codes. Also, some disciplines allow the degree holder to cross over to other industries. However, aggregating the NAICS codes and degree-award disciplines, it is possible to gauge the degree of support given to the five major clusters.

Figure 49: Degree Awards by Discipline
2002-2003



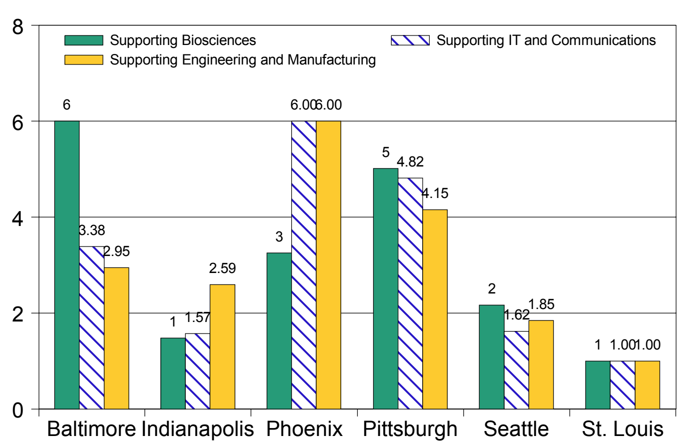
Source: NCES

Here, Pittsburgh shows obvious strengths in its university assets. Although the number of information technology degrees lagged far behind Phoenix's in academic year 2002–2003, Pittsburgh's rankings were comparable to the other four MSAs in life science, natural science and engineering/technician degrees. Of note, Pittsburgh ranks second in the number of information technology degrees.

The Pittsburgh metropolitan area is large, but its population ranked fifth in 2004. Given the decline in population since the 1970s, we must interpret the number of degrees relative to the number of local high-tech workers.

Pittsburgh ranks second for all three categories of high-tech degrees awarded. Phoenix awards the most information technology and engineering/technician degrees, most likely attributable to its fast-growing optics industry. Although Pittsburgh's high-tech industry does not exhibit the same strengths, its universities produce many technical degrees. Given that these are consistent across the three categories, the key to develop the high-tech sectors in Pittsburgh is to provide employment opportunities that leverage the knowledge assets and retain technical talent.

Figure 50: HT Degrees Awarded per HT Worker
Standardized



Sources: Milken Institute, NCES, Economy.com

High-Tech Sector Strengths

Pittsburgh shows strengths in two sectors: "communications and equipment manufacturing," and "manufacturing and reproducing magnetic and optical media." The figures in Appendix E show the LQ trends for these two sectors from 1990 to 2004. We use LQs to show the employment levels relative to the national employment average. In this and the following three sections, we attach the relevant figures in Appendix E.

This "communications and equipment manufacturing" sector is a strength in terms of LQ (see Appendix E, figure 53) but nevertheless shows poor productivity (Figure 55). Indexed to productivity levels in 1990, the sector was lower in 2004 than at the start of the measure. Still, the other five MSAs show growth in productivity for this sector, even though the indexed growth of the U.S. average (1.0) is not promising.

Pittsburgh ranked below both the national average and the other MSAs in 2004. Thus, while the region has a large economic base for this sector, it is not leveraging human resources as well, which makes this sector a conditional strength.

Pittsburgh's "manufacturing and reproducing magnetic and optical media" sector picked up in 1996 and continued to beat the benchmarked MSAs through 1998 (see Appendix E, figure 54). That year, it crossed the national average of 1.00. Since then, it has remained a sector strength.

Local productivity dropped below the national average in 1997, however, as did the rate of productivity. In 2004, productivity remained below the national average (which had itself declined sharply in 2003). Compared to Baltimore, Indianapolis and Phoenix, Pittsburgh did not fare well in productivity growth but managed, in 2004, to rank third among the benchmarked MSAs. As such, this strength again, becomes a conditional strength, dependent on whether or not Pittsburgh can leverage human resources to maintain its position.

Neither manufacturing sector had a strong base in 1990, but both showed rapidly increasing employment with the advent of the dot-com boom and remained strong in 2004, this despite Pittsburgh's comparatively lower performance in sector productivity. Their strengths lie in the availability of firms to employ large numbers of tech graduates. It is therefore vitally important to retain these industries and provide a steady flow of graduates for them.

High-Tech Sector Weaknesses

In high-tech manufacturing, Pittsburgh exhibits three weak sectors: "semi-conductor and other electronic component manufacturing," "nav/measuring/medical/control instruments manufacturing" and "aerospace products and parts manufacturing" (see Appendix E). Pittsburgh has not shown strengths in these sectors over the 14-year period, and they remain undeveloped with low employment. While these sectors may be addressed in the long run, we do not recommend a focus on them for Pittsburgh's high-tech strategy, especially since the weaknesses are entrenched.

As expected, productivity growth was lower than the national average and most of the benchmarked MSAs. As shown in Appendix E, these trends resemble those in the weak high-tech manufacturing sectors. Surprisingly, the "software publishers" sector does not leverage longstanding local university R&D assets. In contrast, Seattle, which does not produce the same numbers of high-tech graduates per high-tech worker, clearly leverages its R&D assets, not just in "software publishers" but also in "data processing services, hosting and related services."

Pittsburgh has failed to boost employment in these sectors, despite the proximity of renowned universities. The reason may be attributed to the lower wages paid to workers in these sectors. While the metropolitan area produces qualified graduates, it seems unable to keep them from moving elsewhere.

A strategy to develop and attract firms in these three sectors is important. It is interesting to note that existing software publishing companies themselves fail to exploit their proximity to Pittsburgh's graduates. The data processing services sector, in fact, seems not to have exploited it throughout the 14-year period. It is plausible that the existing companies in these sectors are not sufficiently focused on high value-added activities, resulting in a mismatch between their operations and the region's leading university talents.

For the medium- to long term, Pittsburgh might promote its leading information technology and engineering tertiary programs. In the short term, the area may experience difficulty in addressing these weaknesses, given the longstanding low employment trends.

High-Tech Sector Opportunities

Appendix E shows the LQ opportunity trends in Pittsburgh's high-tech sectors from 1990 to 2004. The economic base for "computer and peripheral equipment manufacturing" and "other information services" has been strong and fairly consistent.

Again in Appendix E, the indexed productivity growth for the two sectors shows that Pittsburgh has not performed as well as the other MSAs, but does show room for growth.

Intervention to develop or attract new businesses could bolster these sectors. As the data show, there are high numbers of workers, but a relatively moderate number of businesses. In the short term, this leaves a strong possibility for development through venture capital support to leverage knowledge assets. Equally important is the effective leveraging of human resources.

High-Tech Sector Threats

"Audio and video equipment manufacturing," "medical equipment and supplies manufacturing," and "cable and other programs distribution" are three sectors where Pittsburgh shows strengths in employment numbers, but weaknesses in the number of firms. As explained with the case of "audio and video equipment manufacturing" (see Appendix E, figure 73), it is risky to rely on a few anchor firms to support the entire sector.

The "other telecom" and "computer systems design and related services" sectors feature a low number of high-tech workers and a high number of businesses. "Other telecom" sectors refer to sectors that do not fall into the existing telecom categories. With insufficient workers, firms may pull out and trigger a decline in the sector base.

The indexed productivity growth for these five sectors are shown in Appendix E. Pittsburgh performed better than the national average, and potential exists for development. Still, sectors with high numbers of tech firms lack trained employees; and sectors with high numbers of trained employees lack the firms to hire them.

Leveraging Pittsburgh's knowledge assets becomes the key to averting threat. In the short term, of course, it is difficult to boost either employment or the number of firms, but it is possible to avert the threats with planning. Pittsburgh stands to lose workers and businesses, both of which are mobile, if they are sufficiently motivated by economic opportunity elsewhere. Knowledge assets, however, are the result of a cumulative process over long periods of R&D using excellent human capital.

Summary of Industry Cuts

Pittsburgh's high-tech industry shows overall signs of weakness that can chiefly be attributed to the fact that it fails to leverage the area's strong knowledge base. With the exception of two sectors with manufacturing strength — "computers and peripheral equipment" and "other information services" — that weakness has been in evidence since 1990. We also found opportunities, but the entire industry shows threats, including low productivity and insufficient human capital, that must be addressed in order to avoid decline.

We propose key strategies that target specific sectors:

For **sector strengths**, maintaining the status quo will allow Pittsburgh to retain its assets and potentially strengthen these sectors. At the same time, policies may be introduced that encourage practices to maximize the human resource potential.

For **sector weaknesses**, we recommend focusing on primary university R&D as a way to encourage university-based startups and venture capital support. Pittsburgh remains strong in R&D assets and awards a large number of relevant degrees, and further leveraging could address weaknesses, even in the short term.

For **sector opportunities**, business expansion will increase employment and the potential for startups and spin-offs. Increasing both employees and businesses will boost these sectors and offer short-term benefits.

For **sector threats,** an effective strategy must increase either the number of firms or the number of workers. This depends on whether the targeted sector has a comparatively low number of firms or workers.

The following table provides a summary of recommendations.

Table 19: Key Recommendations for High-Tech Manufacturing Industry

	High-Tech Manufacturing Industry	Key Strategy for Short-Term Development
3254	Pharmaceutical and medicine manufacturing	
3333	Commercial and service industry machinery manufacturing	
3341	Computer and peripheral equipment manufacturing	Develop policies that will encourage VC investments at corporate level
3342	Communications and equipment manufacturing	Maintain status quo and develop policies to increase output
3343	Audio and video equipment manufacturing	Encourage the development or inward migration of companies in these industries
3344	Semi-conductor and other electronic component manufacturing	Develop policies to benefit relevant university startups and encourage primary R&D
3345	Nav/Measuring/Medical/Control instruments manufacturing	Develop policies to benefit relevant university startups and encourage primary R&D
3346	Manufacturing and reproducing magnetic and optical media	Maintain status quo and develop policies to increase output
3364	Aerospace products and parts manufacturing	Develop policies to benefit university startups and encourage primary R&D
3391	Medical equipment and supplies manufacturing	Encourage the development or inward migration of companies in these industries

Table 20: Key Recommendations for High-Tech Services Sectors

	High-Tech Services Industry	Key Strategy for Short-Term Development
5112	Software publishers	Develop policies to benefit relevant university startups and encourage primary R&D
5121	Motion picture and video industries	
5171	Wired telecomm carriers	
5172	Wireless telecomm carriers (except satellite)	
5173	Telecomm resellers	
5174	Satellite telecom	Develop policies to benefit relevant university startups and encourage primary R&D
5175	Cable and other programs distribution	Encourage the development or inward migration of companies in these industries
5179	Other telecomm	Increase intake for relevant programs at universities. Develop scholarship programs and local industry linkages in relevant university programs
5181	Internet service providers and web search portals	
5182	Data processing services, hosting, and related services	Develop policies to benefit relevant university startups and encourage primary R&D
5191	Other information services	Develop policies that will encourage VC investments at corporate level
5413	Architectural, engineering and related services	
5415	Computer systems design & related services	Increase the intake for relevant programs at universities. Develop scholarship programs and local industry linkages in relevant university programs
5417	Scientific R&D services	
6215	Medical and diagnostic laboratories	

Regional Economic Overview

Pittsburgh has a strong knowledge base but lacks the necessary industry conditions to exploit it. Development potential certainly exists, but the region appears to lack the conditions to take the region to the next level of economic performance. This can be attributed to several factors:

- **Aversion to risk:** Pittsburgh's investment climate is slow to gain momentum, relative to other cities in this analysis. A comparable number of companies may receive venture capital, but the investment dollars are lower. This is surprising, considering the strong knowledge assets in its innovation pipeline.
- **High corporate tax rates:** The standard of living in Pittsburgh makes it a favorable region for business and professional development. However, the high state corporate tax rates may deter business development and expansion. Baltimore and Indianapolis offer lower corporate taxes.
- **Low high-tech wage-income base:** The low high-tech industry base does not involve a sufficiently high level of high-tech production and is coupled with low high-tech productivity levels. Without a sufficient industry base to engage in high-value production, it becomes difficult to offer high wages to high-level high-tech workers. Taken together, the comparatively lower wage-income in the high-tech industry presents challenges. Without competitive wages, Pittsburgh may be unable to attract and retain the talent that is concentrated in its renowned academic institutions and research base.
- **Lack of anchor firms:** A dearth of anchor firms means less potential for spin-offs and clusters. Some established high-tech clusters do exist, but with just a few anchor firms, the short- to medium-term business climate is vulnerable. This also makes Pittsburgh less desirable for high-tech talent.
- **Insufficiently developed entrepreneurial environment:** Pittsburgh is not strategically positioned to attract large VC investments. The absence of entrepreneurial capacity, coupled with risk aversion, places the area in a highly disadvantaged position for tech development.
- **Lack of immigration:** As explained before, the low wage-income base, the smaller high-tech industry base and lower productivity are weakening the high-tech industry base. As such, the region cannot attract and retain the labor force that can leverage its strong R&D base. Although Pittsburgh's leading institutions produce a quality work force (i.e., the student body), retaining these talents and attracting others become the most critical elements to ensure commercial success in building a high-tech industry.
- **Low workforce development:** Again, while Pittsburgh remains strong in the quality of its work force (i.e., the student body), their numbers in the industry remain low. The good news is that Pittsburgh's high-tech industry productivity remained consistent during the IT crash.

Potential Areas of Focus for the Above Assessment

Kick-Start the Business Environment

Taxation impact is an economic factor that affects decisions of large corporations to locate their headquarters and startups beyond the seeding stage. An unfavorable tax environment therefore, hinders the business development for both large and small companies, and hence entrepreneurial activities. Workers' decision to select safer wage jobs versus risky self-employment is dependent on the differential taxation between these two choices.[27]

Pennsylvania has the third highest corporate net income tax rate in the United States, at 9.99 percent, and the highest flat tax, as well.[28] The high corporate tax rate is disadvantageous to business development on large and small scales. With the understanding that this tax structure is obsolete, members of the Greater Oakland Greater Innovation Zone (GO KIZ) have been pushing for change. But in December 2005, Gov. Edward Rendell vetoed House Bill 515, aimed at corporate tax reform.[29]

Still, Pennsylvania's tax burden, as a percentage of personal income, is relatively low. The state ranks 35th (Table 21) nationwide, and 5th among the six benchmarked MSAs, making it an inexpensive state in which to live. The tax burden includes business taxes because businesses pass on their costs to consumers.[30]

The average U.S. tax burden in 2005 is 10.1 percent; the average U.S. tax burden per capita is more than $3,000.[31] Among the six MSAs, Maryland and Indiana rank highest, with 10.3 percent each. Arizona and Washington come close, at 10.2 percent and 10.0 percent. Pennsylvania follows, with 9.7 percent, and Missouri comes in last, with a state tax burden of 9.4 percent. Though the percentages do not differ substantially, Pennsylvania's tax burden per capita in 2005 was $3,700 compared to Maryland's at $4,500. Pennsylvania's tax burden is comparable to the U.S. average. Considering the cost of living in Baltimore and Pittsburgh, these numbers are not surprising. Baltimore's cost of living in 2004 was 105 percent of the national average, compared to the national average, while Pittsburgh's was only 86 percent.

However, in December 2005, the state House of Representatives passed an increase in the state personal income tax and an expansion of state sales tax to new items and services. These were initiated to make up for property tax reductions.[32] Currently there are proposals submitted that are pushing for ways to shift the property tax.

Missouri: Tax Incentives for the Life Science Industry [33]

The state of Missouri has a comprehensive biotech initiative that is poised to boost its high-tech industry. The Equipment Tax Credit brings benefits to both the industry and distressed communities by means of a three-year, 40 percent tax credit (capped at $75,000). Meanwhile, the Research and Development Tax Credit allows companies to claim up to 6.5 percent of incremental increases over a starting base period of three years.

To develop its life sciences work force, Missouri provides reimbursements to students who work in biotechnology for the first two years of their higher education. In addition, trade organizations—such as the Missouri Biotechnology Industry Organization, Technology Gateway Organization and the American Soybean Association—provide a supply of labor, as well as various services to support projected growth.

The tax incentives are coupled with VC support from Prolog Ventures, RiverVest Venture Partners, Oakwood Medical Investors and Ascension Health Ventures, which raised more than $284 million from 2002 to 2005. Other St. Louis venture capital funds are expected to raise another $250 million.

Table 21: Combined State and Local Tax Burden by State, 2005

	Tax Burden Rank	Tax Burden as a Percentage of Income	Tax Burden Per Capita
Maine	1	13.00%	$4,390
New York	2	12.00%	$5,170
Hawaii	3	11.50%	$4,161
Rhode Island	4	11.40%	$4,327
Wisconsin	5	11.40%	$4,141
Vermont	6	11.10%	$4,005
Ohio	7	11.00%	$3,906
Nebraska	8	10.90%	$3,984
Utah	9	10.90%	$3,122
Minnesota	10	10.70%	$4,409
Arkansas	11	10.50%	$2,993
Connecticut	12	10.50%	$5,400
West Virginia	13	10.50%	$2,996
New Jersey	14	10.40%	$4,971
Kansas	15	10.40%	$3,629
Louisiana	16	10.40%	$3,200
Maryland	17	10.30%	$4,501
Indiana	18	10.30%	$3,503
Kentucky	19	10.30%	$3,199
California	20	10.30%	$4,078
Arizona	21	10.20%	$3,184
Michigan	22	10.10%	$3,686
Wyoming	23	10.10%	$3,802
Washington	24	10.00%	$3,990
Iowa	25	10.00%	$3,479
Mississippi	26	10.00%	$2,739
Idaho	27	10.00%	$3,014
North Carolina	28	10.00%	$3,268
New Mexico	29	9.90%	$2,882
Illinois	30	9.80%	$3,920
Georgia	31	9.80%	$3,377
Massachusetts	32	9.80%	$4,608
South Carolina	33	9.70%	$2,976
Virginia	34	9.70%	$3,820
Pennsylvania	35	9.70%	$3,747
Oregon	36	9.60%	$3,271
Colorado	37	9.50%	$3,758
Nevada	38	9.50%	$3,423
Montana	39	9.50%	$2,878
Oklahoma	40	9.40%	$2,876
Missouri	41	9.40%	$3,282
North Dakota	42	9.40%	$3,170
Texas	43	9.30%	$3,167
Florida	44	9.20%	$3,271
South Dakota	45	8.80%	$2,976
Alabama	46	8.70%	$2,656
Tennessee	47	8.30%	$2,757
Delaware	48	8.00%	$3,128
New Hampshire	49	7.40%	$3,040
Alaska	50	6.40%	$2,452

Sources: Tax Foundation and Bureau of Economic Analysis.

Tax reform efforts in the state House indicate the realization by some politicians that Pennsylvania's business taxes are hurting the state's competitiveness.

Currently, Allegheny County Chief Executive Dan Onorato is focusing on three economic development goals: Brownfields Economic Redevelopment, the airport corridor, and university-based expansion to fuel the high-tech sector. Of note, the airport corridor is deemed as central to the economic growth of the region. [34]

At the municipal agenda-setting level, however, Pittsburgh's leadership has not been stellar. Former Mayor Tom Murphy targeted real estate focused towards amenities and tourism rather than high-tech, a focus out of sync with the best strategy for economic development: leveraging the region's knowledge assets to build up the high-tech industry. The 2005 real estate market, understandably, did not perform well under conditions of low job growth and stagnant population figures.[35] And the region's plans to promote Pittsburgh as a tourist and entertainment attraction may also prove ineffectual for economic growth, including growth in the high-tech industry.[36]

Worse, despite the high corporate tax rates (and outdated tax structure) and sluggish job growth, Mayor Murphy proposed tax hikes, modeling his plan after San Francisco and Philadelphia, both of which had even lower job growth than Pittsburgh from 1990 to 2002.[37]

In November 2005, newly elected Mayor Bob O'Connor proposed a new plan for restoring the area's economic health, among them more cooperation among regional leadership and across different levels. His approach appears to be far less confrontational.[38] The collaboration of Dan Onorato and Bob O'Connor in setting the regional agenda was a good first step for developing the region's high-tech industry.

Seattle's Leadership and Development of High-Tech Industries [39]

We cannot overstate the importance of coordinated leadership in the area of high-tech development. Local governments and agencies often have resources to nurture organizations and industry associations that develop entrepreneurship. Some cities have established special funds to invest in startups, "smart" buildings and incubators.

In Seattle, the Washington Software Alliance was created with support from a state economic development agency, and the local chamber of commerce brought together entrepreneurs from several tech sectors to create the Technology Alliance. Public agencies have hosted meetings and offered support services, including a personal computer user group, activities of the MIT Enterprise Forum, an artificial intelligence Forum and a science-and-technology roundtable within the Technology Alliance.

Legal guidelines address the city's for-profit investments. Using those guidelines, the city's Office of Economic Development initiated a revolving loan fund to assist in the creation of a biotech incubator, using lab space made available when the Fred Hutchinson Cancer Research Center moved to a new site. Because the city could not legally establish venture capital funds, the local chamber organized a network of "angel" investors among area residents with training in high-tech disciplines and vested interests in these areas.

The region's business climate remains quite conservative. Many companies remain small, with just 10 to 20 employees over years, and exhibit little propensity for expansion. Business expansion, of course, implies sharing control with external parties, an anathema to those accustomed to conservative operational methods. But reticence only hinders progress in an economy where innovation and industry linkages are key drivers of growth.

To capture a favorable economic position and technology leadership, rapid expansion of firms and production becomes critical to the transfer of innovation to markets that yield high economic wealth and jobs. Without this transfer or commercialization on a large scale, the region cannot benefit from the high-tech innovation in R&D institutions, regardless of their quality.

Regional leaders may consider initiatives that would boost access to venture capital. Local companies have not received competitive VC funding, and the region could help them gain access to national VCs to sustain initial growth.[40]

Changes in the state corporate tax environment, as well as entrepreneurial culture issues, will serve the region well. These issues inhibit Pittsburgh's ability to leverage its R&D assets. It becomes crucial therefore to initiate these changes at the state level.

Attract and Retain Talent

High-tech companies depend on talented developers and entrepreneurial thinkers, and they reward them with high salaries and sometimes with stock options. High-tech leaders also recognize that rival companies may try to lure away their workers, and that it is crucial to keep them from leaving. An appealing urban environment is one carrot companies use to attract and retain employees.[41]

Migration patterns are largely determined by unfavorable employment and career prospects.[42] These are push factors because people tend to move to places that have more employment and career advantages. Pittsburgh is not immune to this: Since 1990, economic opportunities across all local industries have shrunk, and so has the region's population. People leaving Pittsburgh tend to have higher incomes than do those moving into the area. While the income gap is smaller than it was in the 1980s,[43] it does suggest that the quality of outward migrants remains higher than that of inward migrants.

The area's high-tech industry has experienced longstanding weakness, but successive administrations have failed to address the problems of low employment and sluggish growth. All the while, comparatively attractive regions are not so far away (such as Baltimore and Indianapolis) and pose potential threats to local high-tech development.

Pittsburgh's strength lies in its human capital and its R&D base. The region cannot risk under-utilizing these assets and eventually losing them. But when companies decide to expand or relocate elsewhere, the human capital will move. Spinnaker and Seagate are based in Pittsburgh precisely to exploit the local talent in data storage. Seagate, originally based in California, relocated some of its operations for the express purpose of being close to Carnegie Mellon University.[44] Other high profile companies attempting to exploit Pittsburgh's university assets are Intel and Apple. More recently, Google expanded its operations to Pittsburgh to leverage the local expertise at Carnegie Mellon University with the aim to create more than 100 high-paying jobs.[45] With low employment numbers, however, and fewer skilled workers, companies such as these may see less economic motivation to stay in Pittsburgh.

Indeed, the data show few signs of potential for employment, so Pittsburgh would do well to take full advantage of existing opportunities, such as the presence of Spinnaker and Seagate, and work quickly to enhance their sustainability. Spinnaker was acquired by Network Appliance for $300 million.[46] It is actively enhancing their presence in Pittsburgh.

One way to do this is to attract foreign talent while retaining local graduates. Again, there is the competitive threat from regions that offer more employment opportunities. A 1999 survey of students majoring in business, computer science and engineering at Carnegie Mellon University showed that half wanted to start their own companies but preferred other regions, such as Boston or California.[47]

Also in 1999, the Pennsylvania High Education Assistance Agency introduced two scholarship programs designed to keep students in the area.[48] To qualify for aid, students must agree to work for a full year in Pennsylvania after they graduate. The scholarships could serve as an attractive lure for companies seeking a steady stream of local talent.[49] That same year, the state launched it Sci-Tech scholarships, targeting residents enrolled full time in science or technology disciplines.[50] Sci-Tech recipients must complete internships with Pennsylvanian companies as part of their degree requirements.

The 1999 GI Bill for the New Economy offers financial aid to Pennsylvania high school graduates who don't plan to attend a college or university, but do want technical training.[51] While Pittsburgh may stand to benefit from these scholarship programs, the region faces in-state competition for graduates from Philadelphia. More incentives are crucial to attract and retain high-tech workers. Among which, better wage income packages coupled with the low cost of living in Pittsburgh may work very well to the region's advantages.

Arizona: Commercialization of the Optics Industry [52]

The optics industry in Phoenix (and Arizona) provides a good example of industry linkages; it cuts across the biotech, aerospace, automotive, semiconductor and telecommunications industries, and represents a milestone in local high-tech industry development. The early 1990s saw scientists and entrepreneurs leaving universities to form their own startups, and the state's economic base began to shift from defense and aerospace to optics. Today the optics industry is thriving in Phoenix and elsewhere in the state.

Key to this was the fact that R&D originating from area universities remained local. And the high-tech industry grew through linkages with the optics field. Arizona can, of course, benefit from further collaboration and increased leverage of its knowledge base, but the existing synergy of high-tech talent in optics R&D has created strong commercialization links. This research infrastructure remains one of the internal drivers of the high-tech industry.

The most successful technology companies build near their talent pools. Hence, Pittsburgh might find that tax-free zones work as strong incentives to leverage the region's knowledge assets in attracting new business.[53] In addition, tax-free zones can feed into smart zones, such as the Michigan SmartZones. SmartZones constitute partnerships among universities, industry, research organizations, government, and various community institutions to facilitate the development of clusters to fuel the growth of high-tech businesses and jobs. Primarily, these are oriented around idea commercialization, patents, and other R&D efforts.[54]

Just as the new economy requires companies to be flexible, so too must local governments, universities and businesses think creatively to commercialize innovations. Regions prosper if they develop a human infrastructure of knowledge workers in economic production.[55] For Pittsburgh, the challenge is to broaden the focus of university R&D spending — the R&D pipeline — from primary innovation toward commercialization.[56] Nurturing an efficient center for R&D partnerships with universities might serve as a useful strategy to attract anchors to boost the high-tech industry.

Boost Knowledge-Base Incubation

Incubators boost business growth.[57] They provide support to skilled entrepreneurs who need financial backing. Successful incubation increases the potential to produce high-tech industry leaders. And the success of the U.S. high-tech industry is at least partly attributable to linkages made easier because universities, government agencies and businesses all share proximity.[58]

Successful incubation requires support services, including VC investments. In Pittsburgh, nonprofits like Innovation Works provide such financial and strategic assistance to budding technology companies, and work with universities to boost business opportunities. These kinds of organizations are crucial to the region's growth and, in particular, to growth in high-tech. According to a study by Innovation Works, links to large, national venture capital is necessary for sustained growth.[59]

In its number of VC investments, Pittsburgh is similar to the other MSAs in our analysis but demonstrates little momentum for increasing the investments or the dollar amounts invested. As a result, its entrepreneurial environment remains bleak. With few anchor firms, it may be difficult to establish ties with national VCs and corporations whose investments sustain local development.

Indiana: Incubation, Development Initiatives and Tax Incentives [60]

Indiana University's Advanced Research and Technology Institute (ARTI) has more than a hundred technologies available for licensing and recently established its own life-science incubator in Indianapolis. Statewide, Lilly BioVentures (part of the venture capital division of Eli Lilly and Company) is a $75 million VC fund targeting biotechnology research. The Training Skills Enhancement Fund reimburses up to 50 percent of employee training costs (capped at $200,000) with grants from the Indiana Department of Commerce.

The state also offers two 10-year financial incentives to boost the life sciences industry. In 2003, the governor signed into law Energize Indiana, a $1.25 billion plan to create 200,000 high-wage, highly-skilled jobs in the life sciences and other high-tech fields. Energize Indiana's Indiana Venture Fund is a $144 million investment that allows companies to leverage state money for startups.

The Pittsburgh Life Sciences Greenhouse can serve as an impetus for additional collaborative efforts. In addition, two non-profit organizations, the Pittsburgh Digital Greenhouse—comprising members from the Commonwealth of Pennsylvania, member firms and three leading universities in Pennsylvania, and The Robotics Foundry—an organization aimed at accelerating the robotics industry, merged to become The Technology Collaborative (TTC), whose aim is to develop collaborative industry clusters in advanced electronics, cyber security, and robotics.[61]

Overall, Pittsburgh will need VC support to help leverage its knowledge base so efforts to create incubators can succeed. Local universities have high national, but low regional accreditation, suggesting that the market demand is largely foreign. Innovation Works and similar organizations can work even more closely with universities and companies. A successful strategy will result in long-term collaborations between the universities and businesses in receipt of venture capital support. Tax incentives may also be advantageous to Pittsburgh's high-tech incubation.

Assessment Summary

A summary of strengths, weaknesses, opportunities and threats from the qualitative assessment is given in the following tables.

Table 22: Qualitative SWOT Assessment—Strengths and Weaknesses

SWOT	Assessment
Strengths	**Strong university-based knowledge assets:** Pittsburgh's strengths in its universities come as no surprise. However, the transference of these assets to the high-tech industry is another issue altogether. **Active incubators:** As with any industry anywhere, the presence of incubators is important for creating active mechanisms to transfer the knowledge base to commercialization. Pittsburgh's active incubators strengthen the region's high-tech development. **Presence of established high-tech firms:** Pittsburgh's regional talent have attracted world-class technology companies. Among which, Seagate has established operations in Pittsburgh to leverage the local talent. **Low state and local individual tax burden:** Pittsburgh's relatively low cost of living and tax burdens constitute an attraction for individuals.
Weaknesses	**High risk aversion:** This is reflected in the VC lag. This cultural characteristic has major effects on the entrepreneurial capacity in the region. **Negative migration dynamics:** Migration patterns for Pittsburgh show that inward migrants have lower income than outward migrants. These patterns suggest that the quality of the population is decreasing. Furthermore, there is a challenge of talent retention, despite CMU being a net importer of students. **Lack of clear political focus for high-tech development at the state level** In the existing political leadership, there is a lack of a focused direction on high-tech development. Given the region's insufficiently leveraged knowledge base, leadership is important in establishing the institutional infrastructure, such as effective policies, to enable businesses to capitalize on the region's strengths. **Unfavorable corporate tax structure:** The high corporate net income and CSFI tax structures make Pittsburgh a less attractive region for entrepreneurial activities, as does recent legislation to increase individual income tax.

Table 23: Qualitative SWOT Assessment—Opportunities and Threats

SWOT	Qualitative Assessment
Opportunities	**Scholarship programs in Pennsylvania:** The state's scholarship programs provide opportunities to attract and retain talent in Pennsylvania, though not necessarily Pittsburgh. Given the region's knowledge base, however, similar programs can be developed locally. **Proximity to high-tech talent:** Major firms prefer to be close to major talent. The University of Pittsburgh and Carnegie Mellon University can provide a steady stream of skilled graduates. **University collaborations:** Current R&D collaborations often inspire further collaborations. As we have stated, the knowledge assets in Pittsburgh are not well leveraged. Collaborative efforts are opportunities to increase that leverage and boost the high-tech industry.
Threats	**Competition from economically favorable neighboring regions:** The limitations of the tech industry in Pittsburgh make neighboring regions a draw for Pittsburgh's local talent and for companies in search of a relocation or expansion. **Knowledge base drain:** There is tremendous local talent, but not enough for the high-tech industry. Pittsburgh risks losing its graduates to regions offering greater economic opportunity. **Aging population:** Migration patterns place Pittsburgh at the risk of losing its young talent, without attracting them from various regions. A high-tech industry needs a continuous supply of young and entrepreneurial people. The quality of life in Pittsburgh appears to be more attractive to an older population. Since migration patterns are largely determined by economic opportunities, Pittsburgh's relative lack of these deters inward migration and retention of younger talent.

Brief Recommendations

We propose three recommendations to spur Pittsburgh's high-tech development, each aimed at creating the economic environment Pittsburgh must have if it is to leverage its knowledge base and boost industry performance. Ultimately, this will feed medium- and long-term strategies.

- **Initiate scholarship programs at Pittsburgh universities.**

Given that Pittsburgh lacks the necessary value in the high-tech workforce, the region will benefit from aggressive promotion of scholarship programs for its young people. Pittsburgh's universities can develop more assistance for students entering the technology fields. Considering the competition in Philadelphia for outstanding students, Pittsburgh's high-tech industry might fund scholarships, and anchors such as Seagate Corp. could serve as industry links within the scholarship programs. The maintenance of such industry linkages through scholarship programs facilitates value adding to its high-tech workforce to boost its high-tech industry base.

- **Develop and offer business services to help new and smaller high-tech businesses connect with national VCs and firms. These must be targeted at industry opportunity areas.**

Pittsburgh boasts a number of active companies in receipt of VC investment. These businesses will need to connect with national VCs and corporations if they wish to expand. Likewise, incubators and business development organizations, such as Innovation Works, while helpful, can do more to create sustainable development. Perhaps they can offer more services and develop ways to connect small and new businesses to national players.

The presence of seven key incubators in and around Baltimore indicates the emphasis it places on R&D and commercialization. In 2001, firms in six of Maryland's incubators generated between $184 million and $530 million in gross state product; they also paid an average of more than $36,000 per worker.[62] This was higher than the 2002 state average wage of $35,000.

Pittsburgh covers a larger geographic region and has excellent incubator facilities, but has not had comparable success with the commercialization of its R&D. The area has both for- and nonprofit business incubators,[63] but their effectiveness remains to be seen. Its university assets — its knowledge base — show strengths and opportunities in key industry areas.

- **Increase lobbying efforts to push the high-tech industry on the agenda of the new government.**

Last year's mayoral election brings opportunities to Pittsburgh, although the deficit crisis may divert attention from the equally pressing problem of sluggish economic growth. A high-tech agenda is a regional and state issue and should be taken up to the state government. However, effective representation from the local level is an initial step the region can take to elevate the agenda to the regional and state level. It is not unreasonable to suggest that Pittsburgh may find a short-term solution to the budget crisis by looking at its high-tech industry and the extensive knowledge base found in its universities.

Appendix A: Definition of High-Tech Manufacturing

3254 Pharmaceutical and Medicine Manufacturing
325411 Medicinal and Botanical Manufacturing
325412 Pharmaceutical Preparation Manufacturing
325413 In-Vitro Diagnostic Substance Manufacturing
325414 Biological Product (except diagnostic) Manufacturing

3333 Commercial and Service Industry Machinery Manufacturing
333311 Automatic Vending Machine Manufacturing
333313 Office Machinery Manufacturing
333314 Optical Instrument and Lens Manufacturing

3341 Computer and Peripheral Equipment Manufacturing
334111 Electronic Computer Manufacturing
334112 Computer Storage Device Manufacturing
334113 Computer Terminal Manufacturing
334119 Other Computer Peripheral Equip Manufacturing

3342 Communications Equipment Manufacturing
33421 Telephone Apparatus Manufacturing
33422 Radio and TV Broadcasting and Wireless Comm Equip Mfg
33429 Other Comm Equip Manufacturing

3343 Audio and Video Equipment Manufacturing
33431 Audio and Video Equipment Manufacturing

3344 Semiconductor and Other Electronic Component Manufacturing
334411 Electron Tube Manufacturing
334412 Bare Printed Circuit Board Manufacturing
334413 Semiconductor and Related Device Manufacturing
334414 Electronic Capacitor Manufacturing
334415 Electronic Resistor Manufacturing
334416 Electronic Coil, Transformer, and Other Inductor Mfg
334417 Electronic Connector Manufacturing
334418 Printed Circuitry Assembly
334419 Other Electronic Component Manufacturing

3345 Nav/Measuring/Medical/Control Instruments Manufacturing
334510 Electromedical and Electrotherapeutic Apparatus Manufacturing
334511 Search, Detection, Navigation, Guidance, Aeronautical Instruments
334512 Automatic Environmental Control Mfg for Residential, Comm, and Appliance
334513 Instruments and Related Products Mfg for Measuring Displaying
334514 Totalizing Fluid Meter and Counting Device Manufacturing
334515 Instrument Mfg for Measuring and Testing Electricity and Electric Signals
334516 Analytical Laboratory Instrument Manufacturing
334517 Irradiation Apparatus Manufacturing
334518 Watch, Clock and Part Manufacturing
334519 Other Measuring and Controlling Device Manufacturing

3346 Manufacturing and Reproducing Magnetic and Optical Media
334611 Software Reproduction
334612 Prerecorded Compact Disc (Except Software), Tape, and Record Mfg
334613 Magnetic and Optical Recording Media Manufacturing

3364 Aerospace Products and Parts Manufacturing
336411 Aircraft Manufacturing
336412 Aircraft Engine and Engine Parts Manufacturing
336413 Other Aircraft Parts and Auxiliary Equipment Manufacturing
336414 Guided Missiles and Space Vehicle Manufacturing
336415 Guided Missile and Space Vehicle Propulsion Unit and Parts Mfg
336419 Other Guided Missile and Space Vehicle Parts and Auxiliary Equip Mfg

3391 Medical Equipment and Supplies Manufacturing
339111 Laboratory Apparatus and Furniture Manufacturing
339112 Surgical and Medical Instrument Manufacturing
339113 Surgical Appliance and Supplies Manufacturing
339114 Dental Equipment and Supplies Manufacturing

Appendix B: Definition of High-Tech Services

5112 Software Publishers
51121 Software Publishers

5121 Motion Picture and Video Industries
51211 Motion Picture and Video Production
512191 Teleproduction and Other Postproduction Services
512199 Other Motion Picture and Video Industries

517 Telecommunications
5171 Wired Telecomm Carriers
5172 Wireless Telecomm Carriers (except Satellite)
5173 Telecomm Resellers
5174 Satellite Telecomm
5175 Cable and Other Programs Distribution
5179 Other Telecomm

518 Internet Service Providers, Web Search Portals, and Data Processing Services
5181 Internet Service Providers and Web Search Portals
5182 Data Processing Services, Hosting, and Related Services

5191 Other Information Services

5413 Architectural, Engineering and Related Services
54131 Architectural Services
54133 Engineering Services
54136 Geophysical Surveying and Mapping Services
54137 Surveying and Mapping (except geophysical) Services
54138 Testing Laboratories

5415 Computer Systems Design and Related Services
541511 Custom Computer Programming Services
541512 Computer Systems Design Services
541513 Computer Facilities Management Services
541519 Other Computer Related Services
5417 Scientific R&D Services
54171 R&D in the Physical, Engineering, and Life Sciences
54172 R&D in the Social Sciences and Humanities
6215 Medical and Diagnostic Laboratories
9271 Space Research and Technology

Appendix C: Data Sources

The following databases were used extensively for analysis:

Association of University Technology Managers (AUTM)
http://www.autm.net

Selectoryonline.com
http://www.selectoryonline.com

National Center for Education Statistics (NCES)
http://nces.ed.gov/

PriceWaterHouse Coopers (PWC) Money Tree, Venture Economics
http://www.pwcmoneytree.com/moneytree/
http://ventureeconomics.com/

U.S. Census Bureau
http://www.census.gov/

Economy.com
http://www.economy.com

Internal Revenue Service
http://www.irs.gov

Bureau of Labor Statistics
http://www.bls.gov

Bureau of Economic Analysis
http://www.bea.gov

Federation of Tax Administrators
http://www.taxadmin.org

Tax Foundation
http://www.taxfoundation.org/

Appendix D: Top 100 Performing Metros 1999-2001

1999	2000	2001
1 Seattle WA	1 Austin TX	1 San Diego CA
2 Austin TX	2 Atlanta GA	2 Dallas TX
3 Dallas TX	3 Santa Rosa CA	3 Las Vegas NV-AZ
4 Ventura CA	4 Boulder CO	4 Santa Rosa CA
5 Oakland CA	5 Boise City ID	5 Boise City ID
6 Middlesex NJ	6 San Diego CA	6 McAllen TX
7 Denver CO	7 Orange County CA	7 Oakland CA
8 San Jose CA	8 San Antonio TX	8 Ventura CA
9 Houston TX	9 West Palm Beach FL	9 San Luis Obispo CA
10 Atlanta GA	10 Colorado Springs CO	10 Brownsville TX
11 Orange County CA	11 Fort Collins CO	11 Austin TX
12 San Diego CA	12 Oakland CA	12 Laredo TX
13 Omaha NE	13 Seattle WA	13 Orange County CA
14 Santa Rosa CA	14 Charlotte NC-SC	14 West Palm Beach FL
15 Tampa FL	15 Fort Worth TX	15 Riverside CA
16 San Francisco CA	16 Decatur IL	16 Boulder CO
17 Boulder CO	17 Cedar Rapids IA	17 Fort Worth TX
18 Raleigh NC	18 Portland OR-WA	18 Vallejo CA
19 Ann Arbor MI	19 Provo UT	19 Raleigh NC
20 Phoenix AZ	20 Sacramento CA	20 Orlando FL
21 Washington DC	21 Salt Lake City UT	21 Reno NV
22 Sioux Falls ND	22 Raleigh NC	22 Tampa FL
23 Portland OR	23 Sioux Falls SD	23 Sacramento CA
24 Wilmington DE	24 Phoenix AZ	24 Houston TX
25 Minneapolis MN	25 Dallas TX	25 Washington DC-MD-VA-WV
26 Columbus GA	26 Wilmington DE-MD	26 Fayetteville AR
27 Madison WA	27 Omaha NE-IA	27 Stockton CA
28 Sacramento CA	28 San Luis Obispo CA	28 Phoenix AZ
29 Boston MA	29 Tucson AZ	29 San Francisco CA
30 Albuquerque NM	30 Iowa City IA	30 Naples FL
31 Chicago IL	31 San Jose CA	31 Las Cruces NM
32 Tulsa OK	32 Las Vegas NV-AZ	32 Kansas City MO-KS
33 Wichita KS	33 Tampa FL	33 Houma LA
34 Cincinnati OH	34 Ventura CA	34 Santa Barbara CA
35 Ft Worth TX	35 Brownsville TX	35 San Antonio TX
36 San Antonio TX	36 Riverside CA	36 Jacksonville FL
37 Nashville TN	37 Wilmington NC	37 Albuquerque NM
38 Salt Lake City UT	38 McAllen TX	38 Fort Lauderdale FL
39 Columbus OH	39 Tallahassee FL	39 Lubbock TX
40 Baton Rouge CA	40 Indianapolis IN	40 Denver CO
41 Indianapolis IN	41 Houston TX	41 Colorado Springs CO
42 Kansas City MO	42 Kansas City MO-KS	42 Chico CA
43 Jackson MS	43 Columbia SC	43 Santa Cruz CA
44 Lafayette IN	44 San Francisco CA	44 Sarasota FL
45 Lubbock TX	45 Washington DC-MD-VA-WV	45 Iowa City IA
46 Tucson AZ	46 Yuma AZ	46 Tyler TX
47 New Haven CT	47 Minneapolis MN-WI	47 Melbourne FL
48 New York City NY	48 Naples FL	48 Fort Myers FL

1999	2000	2001
49 Vallejo CA	49 Eau Claire WI	49 Punta Gorda FL
50 Riverside CA	50 Chico CA	50 Sioux Falls SD
51 Boise City ID	51 Columbus GA-AL	51 Modesto CA
52 Milwaukee WA	52 Sarasota FL	52 Indianapolis IN
53 Eugene OR	53 Greenville NC	53 Fort Walton Beach FL
54 Grand Rapids MI	54 Orlando FL	54 Boston MA
55 Fresno CA	55 Salinas CA	55 Salt Lake City UT
56 Tallahassee FL	56 St. Cloud MN	56 Greenville NC
57 Trenton NJ	57 Boston MA	57 Charleston SC
58 Santa Barbara CA	58 Vallejo CA	58 Asheville NC
59 Orlando FL	59 Santa Cruz CA	59 Green Bay WI
60 Stockton CA	60 Nashville TN	60 Brazoria TX
61 Beaumont TX	61 Greeley CO	61 Fort Collins CO
62 Los Angeles CA	62 Myrtle Beach SC	62 Dutchess County NY
63 Pensacola FL	63 Dutchess County NY	63 Provo UT
64 Tacoma WA	64 Waco TX	64 San Jose CA
65 Anchorage AK	65 Baton Rouge LA	65 Anchorage AK
66 Columbia MO	66 Pueblo CO	66 Tallahassee FL
67 Newark NJ	67 Fort Walton Beach FL	67 Tucson AZ
68 Louisville KY	68 Salem OR	68 Myrtle Beach SC
69 Burlington VT	69 Eugene OR	69 Bakersfield CA
70 Memphis TN	70 Lawrence KS	70 Charlotte NC-SC
71 Lexington NE	71 Fargo ND-MN	71 Columbus OH
72 Provo UT	72 Fort Myers FL	72 Pocatello ID
73 Charlotte NC	73 Lincoln NE	73 Wilmington DE-MD
74 Detroit MI	74 Rochester MN	74 Seattle WA
75 Des Moines IA	75 Ann Arbor MI	75 Springfield MO
76 El Paso TX	76 Nassau NY	76 Nassau NY
77 St Louis MO	77 Fort Lauderdale FL	77 Rochester MN
78 Charleston SC	78 Greenville SC	78 Tulsa OK
79 Nassau NY	79 Bloomington IL	79 Portland OR-WA
80 Chattanooga TN	80 Monroe LA	80 Monmouth NJ
81 Fort Lauderdale FL	81 Philadelphia PA-NJ	81 Greeley CO
82 Monmouth NJ	82 Reno NV	82 Atlanta GA
83 Jersey City NJ	83 Denver CO	83 Yuba City CA
84 Philadelphia PA	84 Gainesville FL	84 Billings MT
85 Melbourne FL	85 Tyler TX	85 Trenton NJ
86 Canton OH	86 Lexington KY	86 Bryan TX
87 Birmingham AL	87 Bryan TX	87 Middlesex NJ
88 Cedar Rapids IA	88 Hamilton OH	88 Fresno CA
89 Daytona Beach FL	89 Richland WA	89 Wilmington NC
90 Charleston WV	90 Green Bay WI	90 Nashville TN
91 Elkhart IN	91 Wichita KS	91 Monroe LA
92 Little Rock AR	92 Grand Rapids MI	92 Lancaster PA
93 Gainesville FL	93 Laredo TX	93 Lafayette LA
94 West Palm Beach FL	94 Olympia WA	94 Charlottesville VA
95 Jacksonville FL	95 Tulsa OK	95 Richland WA
96 South Bend IN	96 Springfield MO	96 Medford OR
97 Richmond VA	97 Biloxi MS	97 Visalia CA
98 Appleton WI	98 Lancaster PA	98 Madison WI

Top 100 Performing Metros 1999-2001, cont.

1999	2000	2001
99 Modesto CA	99 La Crosse WI-MN	99 Louisville KY-IN
100 Davenport WA	100 Tacoma WA	100 Huntsville AL

Source: Milken Institute

Appendix D: Top 100 Performing Metros 2002-2003

2002	2003
1 San Diego CA	1 Fayetteville AR
2 Santa Rosa CA	2 Las Vegas NV-AZ
3 Las Vegas NV-AZ	3 Fort Myers FL
4 Ventura CA	4 West Palm Beach FL
5 McAllen TX	5 San Diego CA
6 Boise City ID	6 San Luis Obispo CA
7 San Luis Obispo CA	7 Laredo TX
8 Oakland CA	8 Brownsville TX
9 Brownsville TX	9 McAllen TX
10 Orange County CA	10 Monmouth NJ
11 Riverside CA	11 Anchorage AK
12 West Palm Beach FL	12 Raleigh NC
13 Boulder CO	13 Chico CA
14 Dallas TX	14 Ventura CA
15 Vallejo CA	15 Sacramento CA
16 Laredo TX	16 Houma LA
17 Phoenix AZ	17 Vallejo CA
18 Sacramento CA	18 San Antonio TX
19 Austin TX	19 Washington DC-MD-VA-WV
20 Raleigh NC	20 Riverside CA
21 Houston TX	21 Madison WI
22 Reno NV	22 Reno NV
23 Fayetteville AR	23 Naples FL
24 Stockton CA	24 Modesto CA
25 Tampa FL	25 Houston TX
26 Fort Worth TX	26 Stockton CA
27 Lubbock TX	27 Tampa FL
28 Washington DC-MD-VA-WV	28 Tallahassee FL
29 Colorado Springs CO	29 Fort Lauderdale FL
30 Fort Lauderdale FL	30 Oakland CA
31 Santa Barbara CA	31 Orange County CA
32 Naples FL	32 Fresno CA
33 Houma LA	33 Fort Worth TX
34 Albuquerque NM	34 Dutchess County NY
35 Orlando FL	35 Charleston SC
36 San Antonio TX	36 Colorado Springs CO
37 Fort Myers FL	37 Albany NY
38 Santa Cruz CA	38 Lancaster PA
39 Sarasota FL	39 Albuquerque NM
40 Modesto CA	40 Tucson AZ
41 Chico CA	41 Sarasota FL
42 Kansas City MO-KS	42 Bakersfield CA
43 Dutchess County NY	43 Phoenix AZ
44 Jacksonville FL	44 Middlesex NJ

2002	2003
45 Boston MA	45 Orlando FL
46 Middlesex NJ	46 Charlotte NC-SC
47 Melbourne FL	47 Jacksonville FL
48 Anchorage AK	48 Knoxville TN
49 Fort Collins CO	49 Wilmington NC
50 Monmouth NJ	50 Lincoln NE
51 Denver CO	51 Green Bay WI
52 Myrtle Beach SC	52 Santa Rosa CA
53 Bakersfield CA	53 Nashville TN
54 San Francisco CA	54 Myrtle Beach SC
55 Portland OR-WA	55 Miami FL
56 Provo UT	56 Brazoria TX
57 Tucson AZ	57 Lubbock TX
58 Wilmington DE-MD	58 Tacoma WA
59 Tulsa OK	59 Austin TX
60 Salt Lake City UT	60 Visalia CA
61 San Jose CA	61 Kansas City MO-KS
62 Brazoria TX	62 Lafayette LA
63 Atlanta GA	63 Olympia WA
64 Allentown PA	64 Newburgh NY-PA
65 Trenton NJ	65 Wilmington DE-MD
66 Columbus OH	66 Nassau NY
67 Fresno CA	67 Norfolk VA-NC
68 Lancaster PA	68 Springfield MO
69 Tallahassee FL	69 Richland WA
70 Lafayette LA	70 Melbourne FL
71 Huntsville AL	71 Merced CA
72 Nassau NY	72 Boise City ID
73 Wilmington NC	73 Tulsa OK
74 Indianapolis IN	74 Corpus Christi TX
75 Richland WA	75 Savannah GA
76 Nashville TN	76 Lexington KY
77 Green Bay WI	77 Atlanta GA
78 Olympia WA	78 Dallas TX
79 Minneapolis MN-WI	79 Odessa TX
80 Madison WI	80 Fort Collins CO
81 Baltimore MD	81 Waco TX
82 Visalia CA	82 Ann Arbor MI
83 Odessa TX	83 Longview TX
84 Oklahoma City OK	84 Atlantic NJ
85 Miami FL	85 Eugene OR
86 Charlotte NC-SC	86 Baton Rouge LA
87 Charleston SC	87 Des Moines IA
88 Asheville NC	88 Asheville NC
89 Omaha NE-IA	89 Denver CO
90 Newark NJ	90 Killeen TX
91 Ann Arbor MI	91 Baltimore MD
92 Seattle WA	92 Boulder CO
93 Gainesville FL	93 Salinas CA
94 Hamilton OH	94 Lakeland FL

Top 100 Performing Metros 2002-2003, cont.

2002	2003
95 Salinas CA	95 Birmingham AL
96 Albany NY	96 Pittsburgh PA
97 Springfield MO	97 Jackson MS
98 Spokane WA	98 Appleton WI
99 Longview TX	99 Minneapolis MN-WI
100 Los Angeles CA	100 Santa Barbara CA

Source: Milken Institute

Appendix D: Top 100 Performing Metros 2004-2005

2004	2005
1 Fort Myers Coral FL	1 Palm Bay FL
2 Las Vegas NV	2 Cape Coral Myers FL
3 Phoenix AZ	3 Naples Island FL
4 West Palm Beach Raton FL	4 McAllen TX
5 Daytona Beach FL	5 Deltona Beach FL
6 Sarasota FL	6 Orlando FL
7 Fayetteville AR	7 Washington DC Metropolitan Division
8 Riverside Bernardino CA	8 Fayetteville AR-MO
9 Fort Lauderdale FL	9 Fort Lauderdale Beach FL
10 Monmouth NJ	10 Riverside Bernardino CA
11 Washington DC	11 Las Vegas NV
12 Tampa Petersburg FL	12 Port St. Lucie Pierce FL
13 Boise City ID	13 Ocala FL
14 Portland ME	14 Tucson AZ
15 Naples FL	15 Phoenix AZ
16 San Diego CA	16 Santa Barbara Maria CA
17 Tucson AZ	17 Santa Ana CA
18 McAllen TX	18 Bremerton WA
19 Trenton NJ	19 Camden NJ
20 Albuquerque NM	20 Clarksville TN-KY
21 Anchorage AK	21 Reno NV
22 Sacramento CA	22 Charleston SC
23 Vallejo CA	23 Provo UT
24 Brownsville Benito TX	24 Sarasota FL
25 Merced CA	25 Tampa Petersburg FL
26 Reno NV	26 Gainesville FL
27 Huntsville AL	27 West Palm Beach Raton Beach FL
28 Laredo TX	28 Huntsville AL
29 Orlando FL	29 San Diego Marcos CA
30 Ventura CA	30 Bakersfield CA
31 Melbourne Bay FL	31 Stockton CA
32 Tacoma WA	32 Boise City ID
33 Green Bay WI	33 Lakeland FL
34 Raleigh Hill NC	34 Sacramento CA
35 Orange County CA	35 Madison WI
36 Knoxville TN	36 Trenton NJ
37 Provo UT	37 Tacoma WA
38 New London CT	38 Oxnard Oaks CA
39 Newark NJ	39 Ogden UT

2004	2005
40 Stockton CA	40 Fresno CA
41 Gainesville FL	41 Vallejo CA
42 Pensacola FL	42 Portland ME
43 Madison WI	43 Albuquerque NM
44 Des Moines IA	44 Killeen Hood TX
45 Norfolk Beach News VA	45 Raleigh NC
46 Providence RI	46 Fort Collins CO
47 Fresno CA	47 Modesto CA
48 Jacksonville FL	48 Poughkeepsie NY
49 Visalia CA	49 Anchorage AK
50 Charlotte Hill NC	50 Manchester NH
51 Barnstable MA	51 Jacksonville FL
52 Savannah GA	52 Nashville TN
53 Santa Barbara Maria CA	53 Bethesda MD
54 Newburgh NY	54 Knoxville TN
55 Spokane WA	55 Pensacola Pass FL
56 Baltimore MD	56 Honolulu HI
57 Charleston SC	57 San Antonio TX
58 Olympia WA	58 Austin Rock TX
59 Tallahassee FL	59 Wilmington NC
60 Indianapolis IN	60 Baltimore MD
61 Dutchess County NY	61 San Luis Obispo Robles CA
62 Springfield MO	62 Des Moines IA
63 Honolulu HI	63 Richmond VA
64 Austin Marcos TX	64 Virginia Beach News VA-NC
65 Lancaster PA	65 Oklahoma City OK
66 Jackson MS	66 Albany NY
67 Lakeland Haven FL	67 Visalia CA
68 Nashville TN	68 Amarillo TX
69 Hamilton OH	69 Charlotte NC-SC
70 Salem OR	70 Allentown PA-NJ
71 Amarillo TX	71 Colorado Springs CO
72 Atlanta GA	72 Lincoln NE
73 Modesto CA	73 Miami Beach FL
74 San Luis Obispo Robles CA	74 Norwich London CT
75 Wilmington DE	75 Providence Bedford River RI-MA
76 Waco TX	76 Nassau NY
77 Miami FL	77 Springfield MO
78 San Antonio TX	78 Savannah GA
79 Fort Pierce St. Lucie FL	79 Hagerstown MD-WV
80 Lincoln NE	80 Fort Worth TX
81 Eugene OR	81 Fayetteville NC
82 Minneapolis/St. Paul MN	82 Tallahassee FL
83 Chattanooga TN	83 Minneapolis Paul MN-WI
84 Philadelphia PA	84 Jackson MS
85 Odessa TX	85 Lubbock TX
86 Montgomery AL	86 Lake County County IL
87 Colorado Springs CO	87 Salt Lake City UT
88 Atlantic May NJ	88 Edison NJ
89 Harrisburg PA	89 Oakland CA

Top 100 Performing Metros 2004-2005, cont.

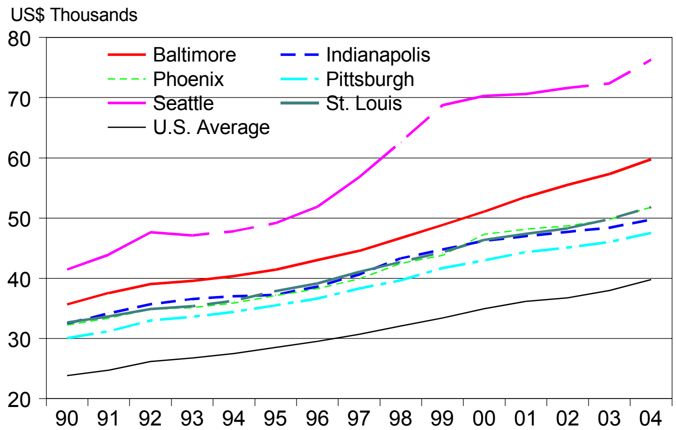
2004		2005	
90	Bakersfield CA	90	Merced CA
91	Baton Rouge LA	91	Wilmington DE
92	Asheville NC	92	Boulder CO
93	Allentown PA	93	Spokane WA
94	Seattle WA	94	Little Rock Little Rock AR
95	Fort Worth TX	95	Portland OR-WA
96	Nassau NY	96	Eugene OR
97	South Bend IN	97	Lexington KY
98	Ocala FL	98	Brownsville TX
99	Boulder CO	99	Green Bay WI
100	Longview TX	100	Salem OR

Source: Milken Institute

Appendix E: Miscellaneous Charts

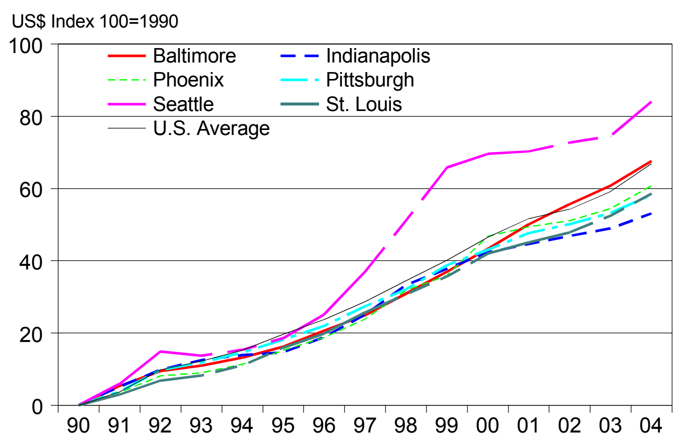
Non-High-Tech Wages

Figure 51: Non-HT Wages per Non-HT Worker
1990-2004



Source: Economy.com

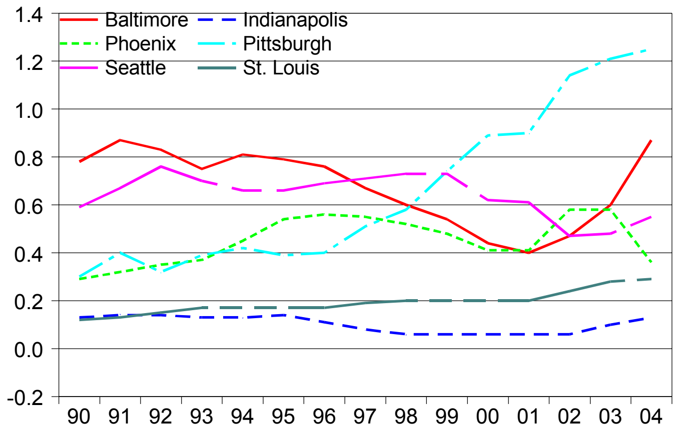
Figure 52: Non-HT Wages per Non-HT Worker
Indexed Growth, 1990-2004



Source: Economy.com

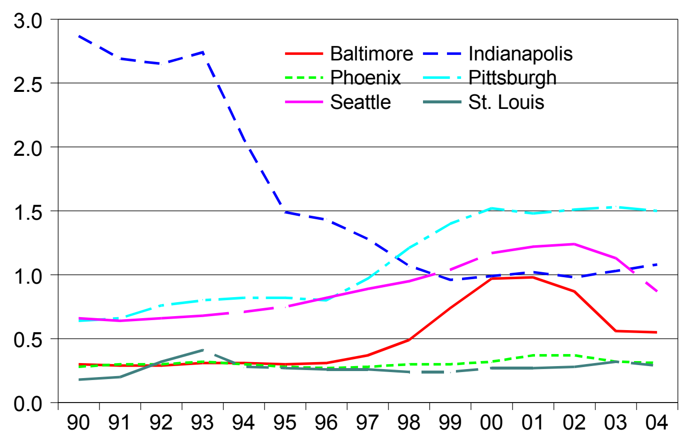
Pittsburgh's Sector Strengths

Figure 53: Comms. Equipment Manufacturing LQs
1990-2004



Source: Economy.com

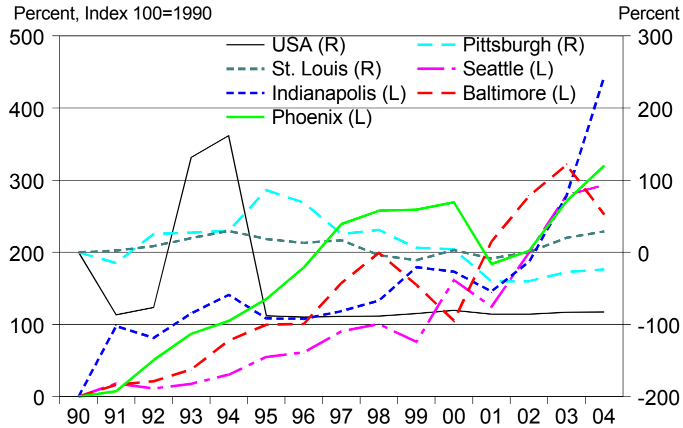
Figure 54: Mfg./Reproducing Mag./Optic. Media LQs
1990-2004



Source: Economy.com

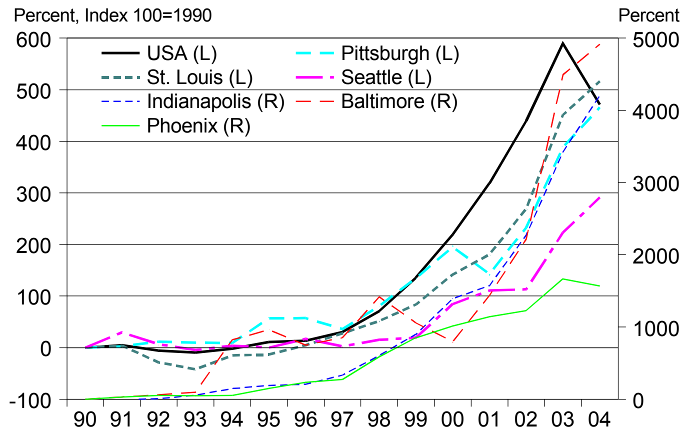
Pittsburgh's Sector Strengths

Figure 55: Communications Equipment Productivity
Indexed Growth



Source: Economy.com

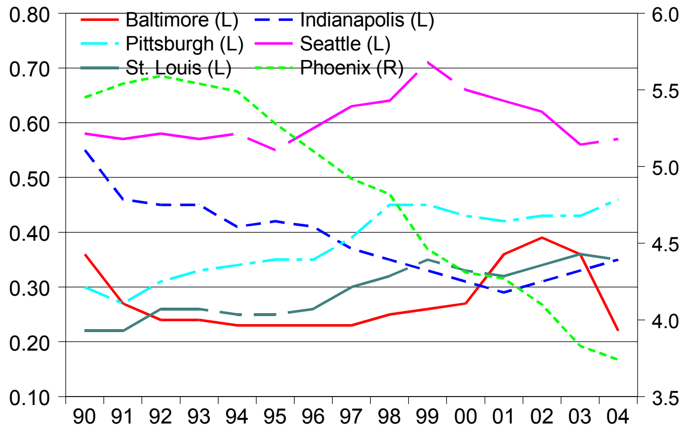
Figure 56: Magnetic & Optical Media Productivity
Indexed Growth



Source: Economy.com

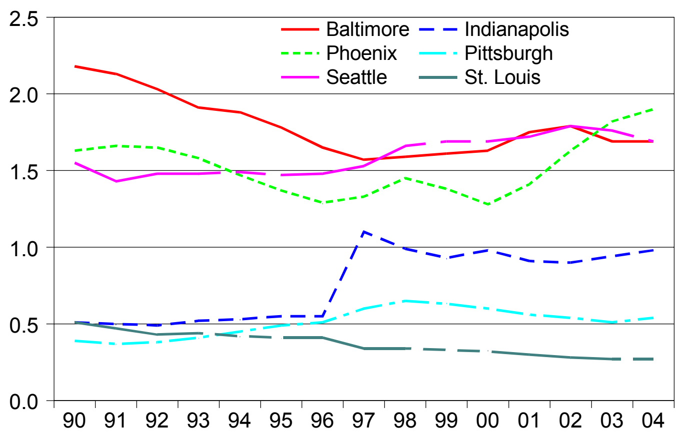
Pittsburgh's Sector Weaknesses

Figure 57: Semiconductor & Other Elec. Comp. LQs
1990-2004



Source: Economy.com

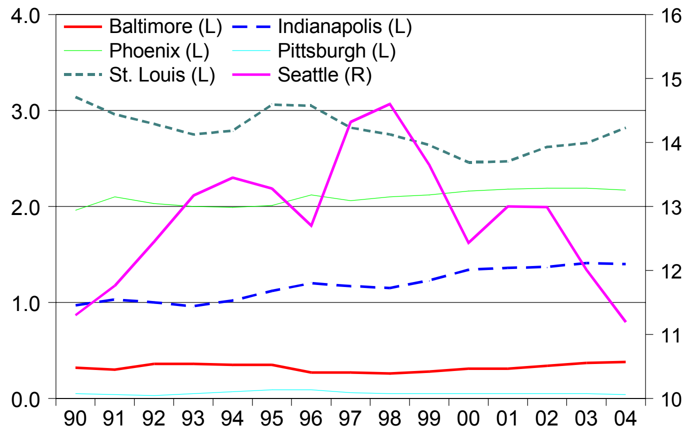
Figure 58: Nav/Measuring/Med./Ctrl. Instr. LQs
1990-2004



Source: Economy.com

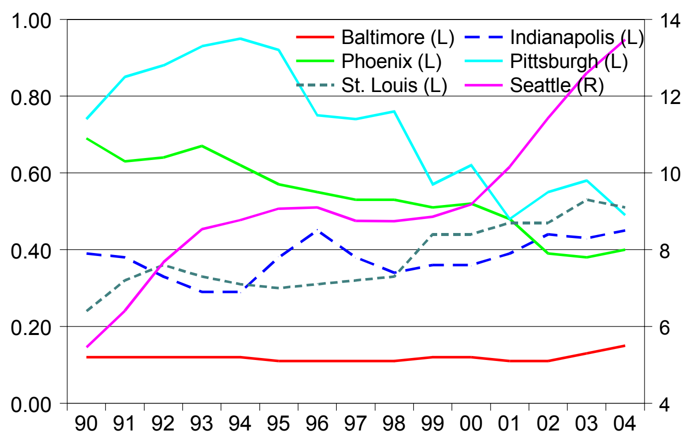
Pittsburgh's Sector Weaknesses

Figure 59: Aerospace Products & Parts Mfg. LQs
1990-2004



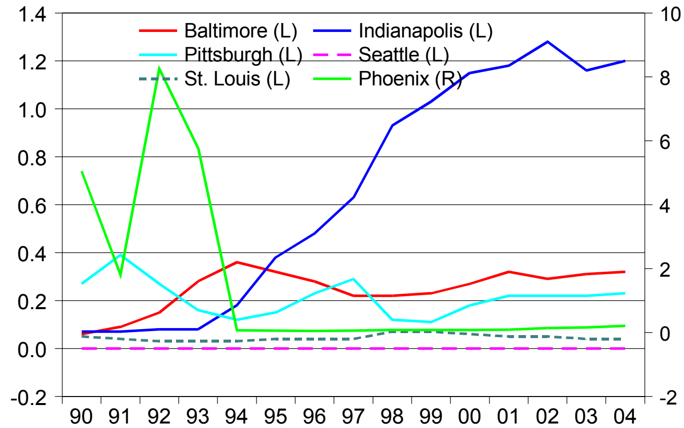
Source: Economy.com

Figure 60: Software Publishers LQs
1990-2004



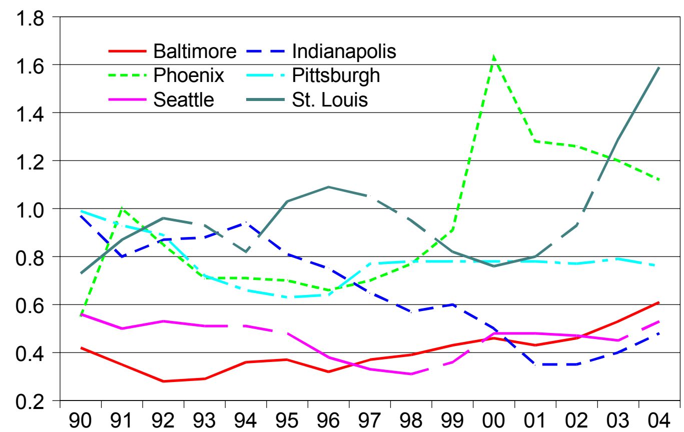
Source: Economy.com

Figure 61: Satellite Telecomm LQs
1990-2004



Source: Economy.com

Figure 62: Data Pro., Hosting & Related Serv. LQs
1990-2004



Source: Economy.com

Pittsburgh's Sector Weaknesses

Figure 63: Semiconductor & Elec. Comp. Productivity
Indexed Growth

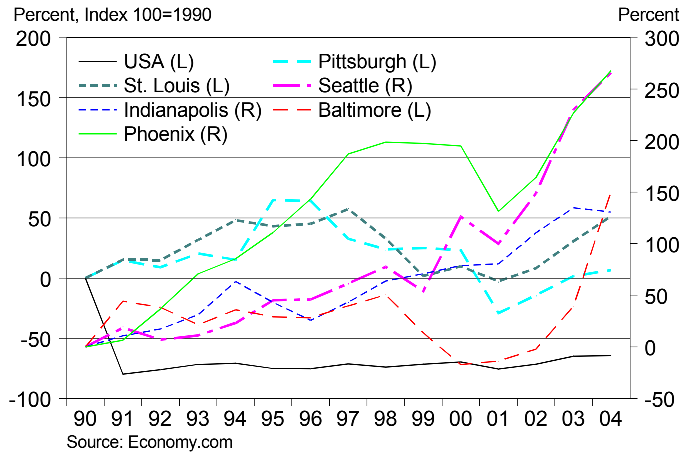


Figure 64: Nav/Meas./Med./Ctrl. Instr. Productivity
Indexed Growth

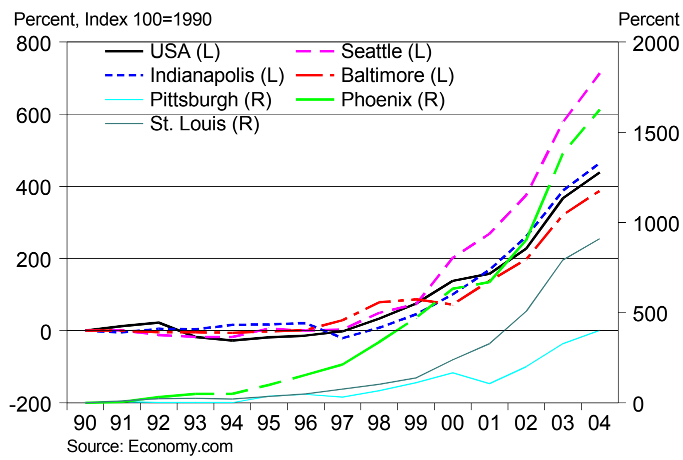
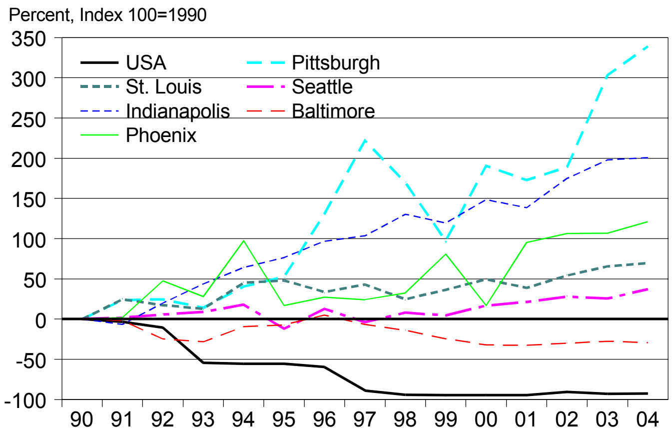
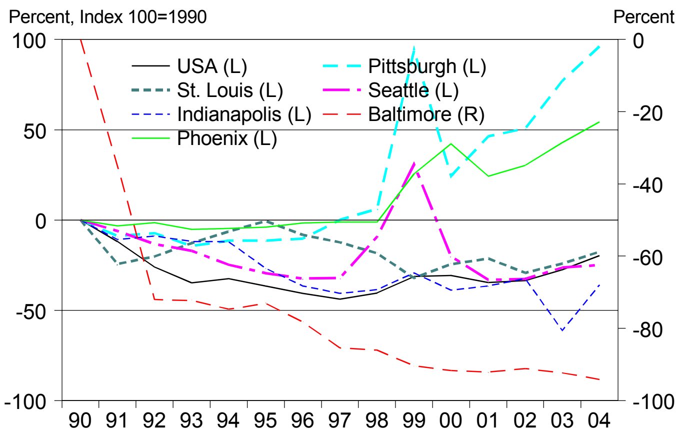


Figure 65: Aero. Products & Parts Mfg. Productivity
Indexed Growth



Source: Economy.com

Figure 66: Software Publishers Productivity
Indexed Growth



Source: Economy.com

Pittsburgh's Sector Weaknesses

Figure 67: Satellite Telecomm Productivity
Indexed Growth

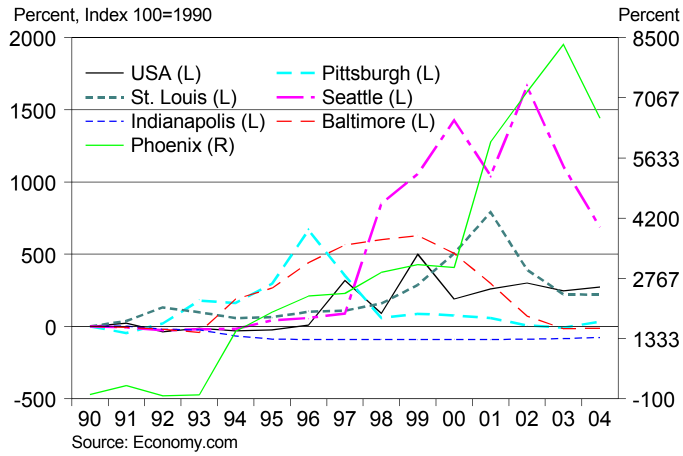
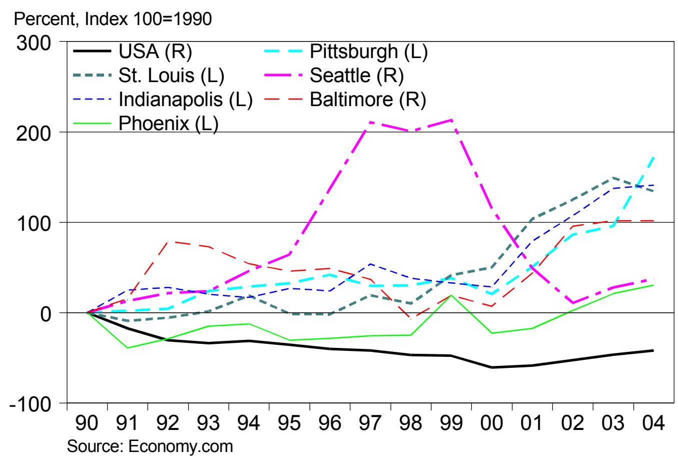
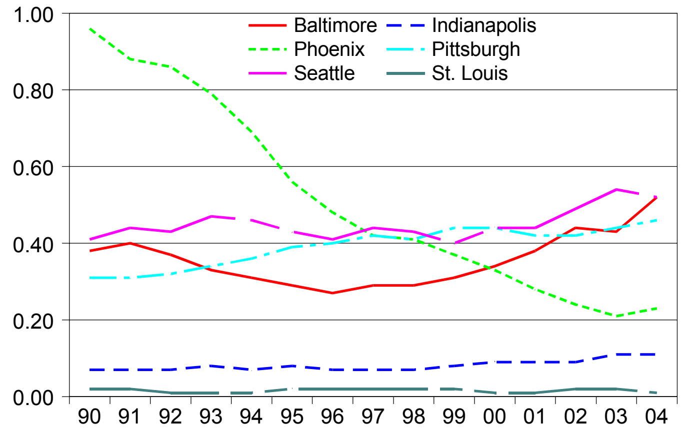


Figure 68: Data Pro., Hosting & Serv. Productivity
Indexed Growth



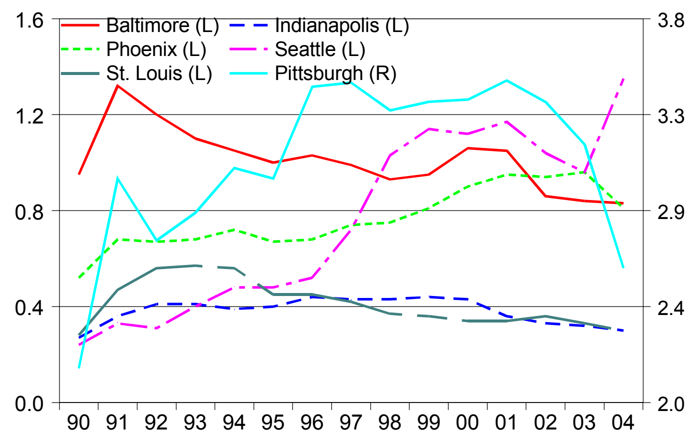
Pittsburgh's Sector Opportunities

Figure 69: Comp. & Peripheral Equip. Mfg. LQs
1990-2004



Source: Economy.com

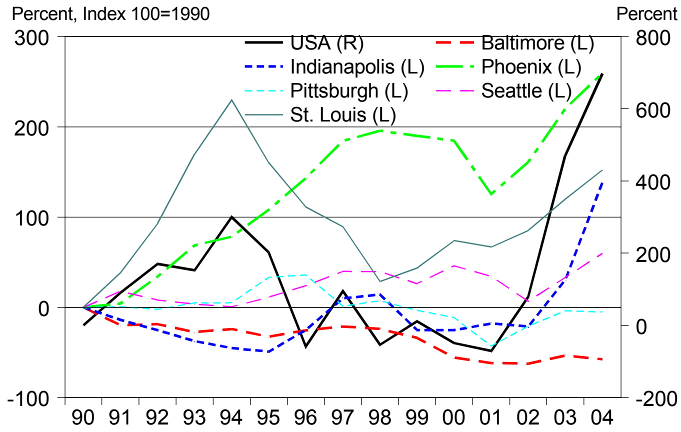
Figure 70: Other Information Services LQs
1990-2004



Source: Economy.com

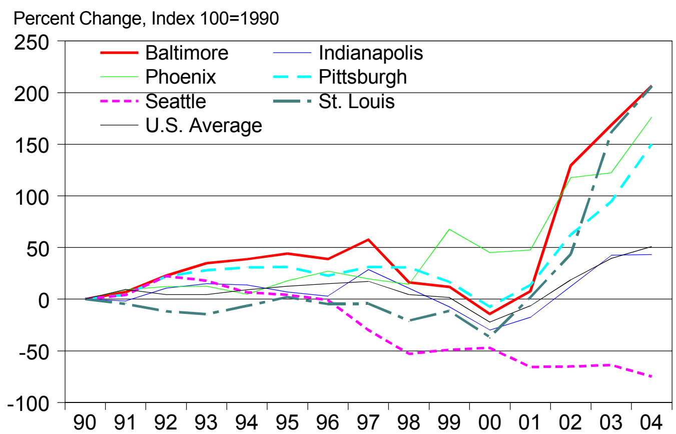
Pittsburgh's Sector Opportunities

Figure 71: Comp. & Peripheral Equip. Productivity
Indexed Growth



Source: Economy.com

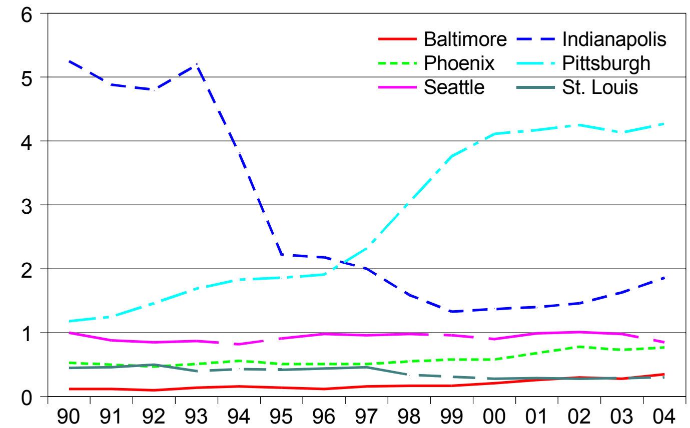
Figure 72: Other Info. Serv. Productivity
Indexed Growth



Source: Economy.com

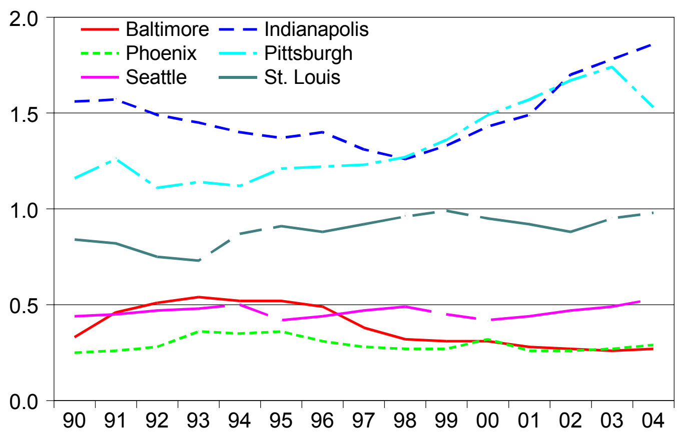
Pittsburgh's Sector Threats

Figure 73: Audio & Video Equipment Mfg. LQs
1990-2004



Source: Economy.com

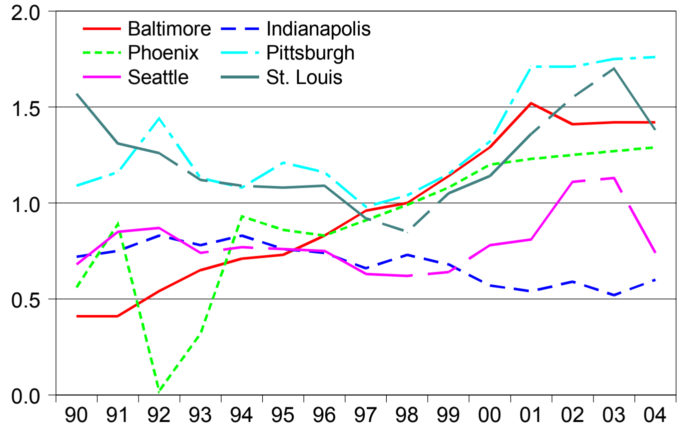
Figure 74: Med. Equip. & Supplies Mfg. LQs
1990-2004



Source: Economy.com

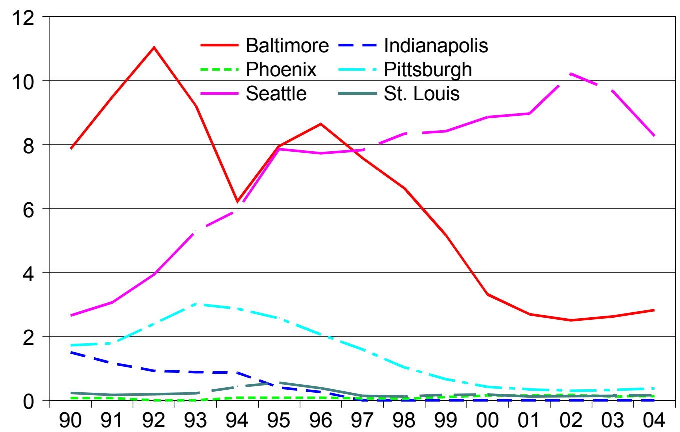
Pittsburgh's Sector Threats

Figure 75: Cable & Other Programs Distribution LQs
1990-2004



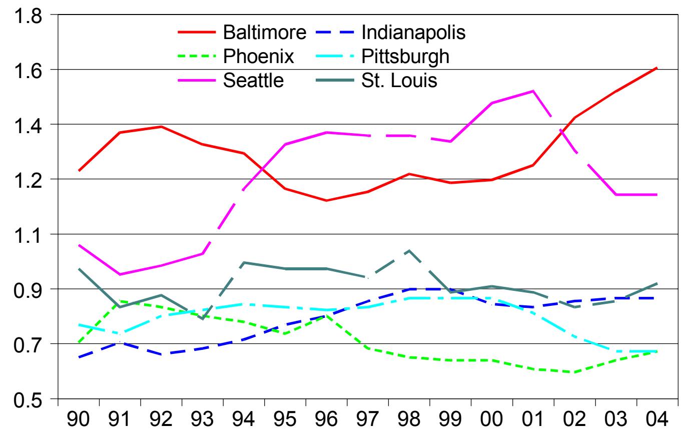
Source: Economy.com

Figure 76: Other Telecomm LQs
1990-2004



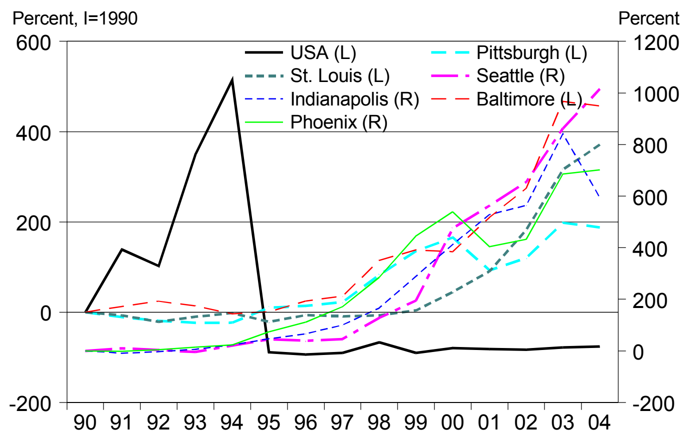
Source: Economy.com

Figure 77: Comp. Sys. Design & Related Serv. LQs
1990-2004



Source: Economy.com

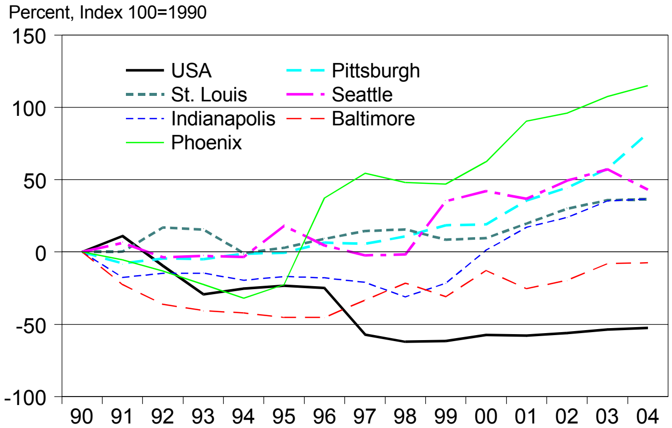
Figure 78: Audio & Video Equip. Mfg. Productivity
Indexed Growth



Source: Economy.com

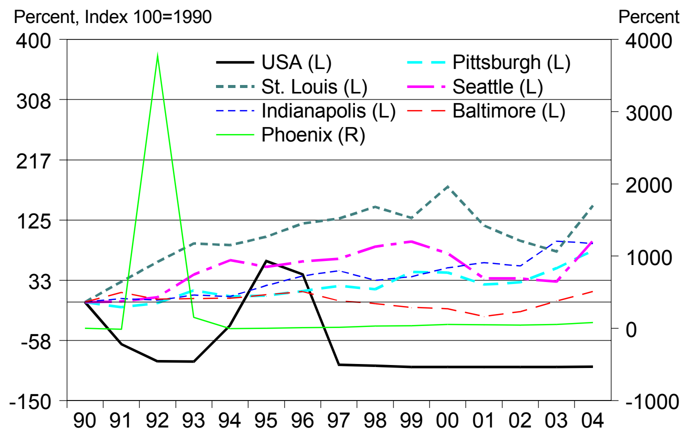
Pittsburgh's Sector Threats

Figure 79: Med. Equipment & Supplies Productivity
Indexed Growth



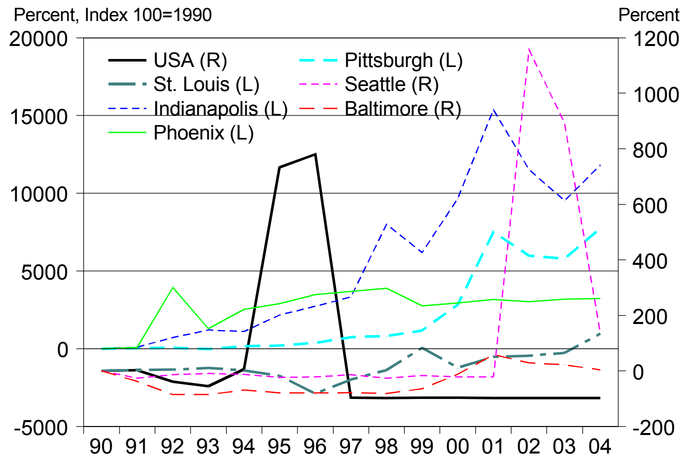
Source: Economy.com

Figure 80: Cable & Other Prog. Distri. Productivity
Indexed Growth



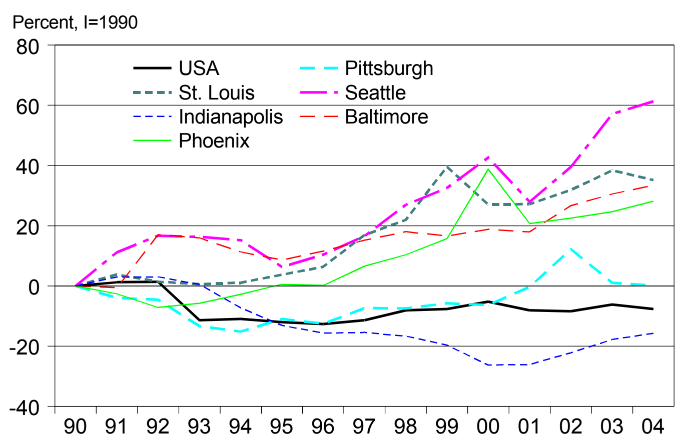
Source: Economy.com

Figure 81: Other Telecomm Productivity
Indexed Growth



Source: Economy.com

Figure 82: Comp. Sys. Design & Serv. Productivity
Indexed Growth



Source: Economy.com

Endnotes

[1] Porter, Michael, E. 2002. Pittsburgh. Clusters of Innovation. Harvard University. Clusters on Competitiveness.

[2] Drucker, P. 1993. *Post-Capitalist Society*. New York: Harper Business.

[3] Rincon, M. & R. Kadi. 2004. Strategies Towards the Knowledge Society: Case Study from a Developing Country. Working Paper.

[4] Bell, D. 1973. *The Coming of the Post-Industrial Society. A Venture in Social Forecasting.* New York: Basic Books.

[5] Schiller, D. 1999. *Digital capitalism: Networking the Global Market System.* Cambridge, MA: MIT Press.

[6] Drucker, P. 1993. *Post-Capitalist Society*. New York: Harper Business.

[7] Rincon, M. & R. Kadi. 2004. Strategies Towards the Knowledge Society: Case Study from a Developing Country. Working Paper.

[8] United Nations Economic Commission for Europe. 2002. *Concept, Outline, Benchmarking and Indicators*. New York. Geneva: United Nations Publications.

[9] DeVol, R., Perry Wong, Junghoon Ki, Armen Bedroussian & Rob Koepp. 2004. America's Biotech and Life Science Clusters. San Diego's Position and Economic Contributions. Santa Monica: Milken Institute.

[10] DeVol, R., Rob Koepp, John Ki, and Frank Fogelback. 2004. *California's Position in Technology and Science*. Santa Monica: Milken Institute.

[11] Saxenian, A. 1999. Reversed Brain Drain.

[12] DeVol, R., Perry Wong, Junghoon Ki, Armen Bedroussian & Rob Koepp. 2004. *America's Biotech and Life Science Clusters. San Diego's Position and Economic Contributions*. Santa Monica: Milken Institute.

[13] DeVol. Ross. 1999. America's High-Tech Economy. *Growth, Development, and Risks for Metropolitan Areas.* Santa Monica: Milken Institute.

[14] http://www.cmu.edu/home/about/about_history.html.

[15] http://www.salk.edu/jonassalk/.

[16] http://members.tripod.com/~MitchellBrown/samples/CNET_java.html.

[17] Devol, R. and Frank Fogelbach. 2003. *Milken Institute Best Performing Cities*. Santa Monica: Milken Institute.

[18] Haulk, Jake, Paul F. Stifflemire 2002. *Pittsburgh's Job Growth Rate has been Dismal.* The Allegheny Institute for Public Policy.

[19] Haulk, Jake, Paul F. Stifflemire 2002. Pittsburgh's Job Growth Rate has been Dismal. The Allegheny Institute for Public Policy.

[20] http://www.bizjournals.com/pittsburgh/stories/2003/07/28/daily42.html.

[21] Pittsburgh. Economics Division, PNC Financial Services Group.

[22] DeVol, Ross. *America's High-Tech Economy: growth, Development and Risks for Metropolitan Areas.* Santa Monica: Milken Institute.

[23] Lee, Myeong-Ho & In Jeong Hwang. 2003. Determinants of Corporate R&D Investment: An Empirical Study Comparing Korea's IT Industry with its Non-IT Industry. *ETRI Journal*, 25: 4. Aug 2003.

[24] Gertler, Meric S., Uyen Quach & Tara Vinodrai. 2005. Life Science Innovation Systems: Lessons from ISRN. http://www.utoronto.ca/onris/pdf/ONRIS%20Fall%20Workshop%202005%20-%20Life%20Sciences%20v3.ppt.

[25] Entrepreneurial Vitality Scorecard, Carnegie Mellon University. 1998.

[26] *Pittsburgh. Economics Division, PNC Financial Services Group.*

[27] Schuetze, Herbert, J. and Donald Bruce. 2004. *The Relationship Between tax Policy and Entrepreneurship: What We Know and What We Should Know*. Conference on Self-Employment, march 22nd, 2004. Stockholm, Sweden. Organized by the Economic Council of Sweden.

[28] http://www.issuespa.net/articles/13001/.

[29] http://www.state.pa.us/papower/cwp/view.asp?Q=448542andA=11.

[30] http://www.retirementliving.com/RLtaxes.html.

[31] http://www.retirementliving.com/RLtaxes.html.

[32] http://www.pabar.org/legisspecialsession05.shtml.

[33] http://www.bio-itworld.com/archive/061503/insights_midwest.html.

[34] http://www.post-gazette.com/pg/06054/659564.stm. Accessed: Mar 1, 2006.

[35] http://online.wsj.com/public/article/SB112119640720383572-KpZLmVTMBhPKDA3gpvQ8cTjh87w_20060712.html?mod=tff_main_tff_top.

[36] Haulk, Jake, Paul F. Stifflemire 2002. *Pittsburgh's Job Growth Rate has been Dismal*. The Allegheny Institute for Public Policy.

[37] Haulk, Jake, Paul F. Stifflemire 2002. *Pittsburgh's Job Growth Rate has been Dismal*. The Allegheny Institute for Public Policy.

38 http://www.post-gazette.com/pg/05313/603160.stm.

39 Sommers, Paul, Daniel Carlson, Michael Stanger, Saijun Xue, Mika Miyasato. 2000. *Ten Steps to a High Tech Future: The New Economy in Metropolitan Seattle*. Center on Urban and Metropolitan Policy. The Brookings Institution.

40 Innovation Works. 2005.

41 Sommers, Paul, Daniel Carlson, Michael Stanger, Saijun Xue, Mika Miyasato. 2000. *Ten Steps to a High-Tech Future: The New Economy in Metropolitan Seattle*. Center on Urban and Metropolitan Policy. The Brookings Institution.

42 Gradeck, R. and Jerry Paytas. 2000. *Migration and Regional Growth*. Center for Economic Development, Carnegie Mellon University.

43 Center for Economic Development, Carnegie Mellon University. 2003. *The Root of Pittsburgh's Population Drain*.

44 H. John Heinz III School of Public Policy and Management. 2000. Entrepreneurial Pittsburgh: *Uncovering the New Economy. Key Findings and Policy Recommendations.*

45 http://pittsburghlive.com/x/tribune-review/business/s_404601.html.

46 http://www.netapp.com/news/press/news_rel_20040218.

47 Survey of 104 students pursuing degrees in Business, Engineering, and Computer Science at Carnegie Mellon. 1999.

48 http://www.pheaa.org/specialprograms/nets/New_Economy_Technology_Scholarship.shtml.

49 http://www.pahouse.com/youngblood/pr/198102199.

50 http://www.pheaa.org.

51 H. John Heinz III School of Public Policy and Management. 2000. *Entrepreneurial Pittsburgh: Uncovering the New Economy*. Key Findings and Policy Recommendations.

52 The Emerging Cluster of Arizona. *Collaborative Economics*.

53 H. John Heinz III School of Public Policy and Management. 2000. *Entrepreneurial Pittsburgh: Uncovering the New Economy*. Key Findings and Policy Recommendations.

54 http://medc.michigan.org/smartzones/program/.

55 Florida, Richard, "Toward the Learning Region," Futures 27, 5 (June 1995): 527-536.

56 H. John Heinz III School of Public Policy & Management. 2000. *Entrepreneurial Pittsburgh: Uncovering the New Economy. Key Findings and Policy Recommendations.*

[57] Gonzalez, Marisela, & Rafael Lucea. 2001. *The Evolution of Business Incubation.* Center for Economic Development, Carnegie Mellon University.

[58] RESI Research nd Consulting. 2001. Maryland Incubator Impact Analysis.

[59] Innovation Works. 2005.

[60] http://www.bio-itworld.com/archive/061503/insights_midwest.html.

[61] http://www.techcollaborative.org/default.aspx?id=about_ttc.

[62] Feldman, Maryann and Francis Johana. "Fortune Favors the Prepared Region." *Forthcoming in European Planning Studies.* http://www.rotman.utoronto.ca/feldman/papers/MDBiotechCluster2.0.pdf. Accessed on Feb 28, 2006.

[63] Gonzalez, Marisela, and Rafael Lucea. 2001. *Pittsburgh's Business Incubators.* http://www.smartpolicy.org/pdf/incprofiles.pdf.

About the Authors

Ross DeVol is Director of Regional Economics at the Milken Institute. He oversees the Institute's research on the dynamics of comparative regional growth and performance, and technology and its impact on regional and national economies. DeVol is an expert on the intangible economy and how regions can prepare themselves to compete in it. He authored the study *America's High-Tech Economy: Growth, Development, and Risks for Metropolitan Areas*, an examination of how clusters of high-technology industries across the country affect economic growth in those regions, and *America's Biotech and Life Science Clusters*, among many others. He also created the *Best Performing Cities Index*, and annual ranking of U.S. metropolitan areas that shows where jobs are being created and economies are growing. Prior to joining the Institute, DeVol was senior vice president of global Insight, Inc. (formerly Wharton Econometric Forecasting), where he supervised the Regional Economic Services group. DeVol earned an M.A. in economics at Ohio University.

Perry Wong is a Senior Managing Research Economist in Regional Economics at the Milken Institute. He is an expert on regional economics, development and econometric forecasting and specializes in analyzing the structure, industry mix, development, and public policies of a regional economy. He designs, manages, and performs research on labor and workforce issues, the relationship between technology and economic development, trade and industry, with a focus on economic policy development and implementation in both leading and disadvantaged regions. Prior to joining the Institute, Wong was a senior economist and director of regional forecasting at Global Insight, Inc. (formerly Wharton Econometric Forecasting), where he managed regional, state, and metropolitan area forecasts and provided consultation. Wong earned a master's degree in economics at Temple University in 1990 and completed all course requirements for his Ph.D.

Benjamin Yeo is a Research Analyst in Regional Economics at the Milken Institute and a Ph.D. candidate at Pennsylvania State University. Yeo's doctoral dissertation is aimed at developing a theory of sustainability for the knowledge economy. His expertise comprises information technology, planning and knowledge management for e-business and economic development, information systems/process management, and national information policy studies. Yeo obtained his undergraduate and graduate degrees at the School of Communication and Information at Nanyang Technological University in Singapore.

MILKEN INSTITUTE

1250 Fourth Street • Santa Monica, CA 90401
Phone: 310.570.4600 • Fax: 310.570.4601 • E-mail: info@milkeninstitute.org
www.milkeninstitute.org