

Appendix A: Performance of Pittsburgh’s leading advanced industries

This appendix sets out the approach and findings from a detailed examination of leading advanced industry drivers found in the Pittsburgh region. The focus on leading industries is not about picking individual corporate winners and losers. Rather, it is about identifying those crucially important industries that have significant and quantifiable growth momentum in the regional economy and that can offer the promise of good quality jobs and economic prosperity.

Approach to this study

Research shows the significance of innovation for economic growth and rising living standards. Studies have found that 90 percent of the variation in the growth of worker incomes across nations is related to how effectively human and physical capital is used, as measured by productivity gains (a surrogate measure of the impact of innovation).³⁴ The Congressional Budget Office estimates that nearly half of U.S. projected growth in the 2014–2024 period will be driven by rising productivity from innovation.³⁵ Economists at the Federal Reserve Bank of Cleveland found that increased innovation, as evidenced by growing levels of patent activity, is one of the most significant factors in determining a state’s level of per capita income, outstripping other factors behind growing per capita income such as tax burdens, public infrastructure, and the size of private financial markets.³⁶

Broad industry categories used in report

- *Advanced industries*—innovation-driven, skilled, and export-oriented industries as identified by the Brookings Institution
- *Advanced business & health services*—key complements to advanced industries that may also drive growing economic activity

In line with the new imperative for regions to focus on innovation-based economic growth, the Brookings Institution has identified a set of “advanced industries,” defined as industries that invest significantly in science, technology, engineering, and math (STEM) workers.³⁷ These industries anchor American economic well-being by “... encompass[ing] the nation’s highest-value economic activity. As such, these industries are the country’s best shot at innovative, inclusive, and sustainable growth.”³⁸

Advanced Industries include a wide range of manufacturing industries as well as engineering, software/computer services, and commercial research and testing services actively involved in exports and that bring new income into local economies.

Complementing these advanced industries at a regional level are advanced business and health services, which in Pittsburgh are a large part of the export economy. They serve customers within and outside the region, require a skilled workforce, advance and/or deploy leading technologies, and provide the business and technical services needed for the success of advanced industries.

A full list of advanced industries, including advanced business and health services, appears at the end of this appendix in Table A-9.

Identifying leading industry clusters in Pittsburgh

While this paper discusses three major clusters—advanced manufacturing, life sciences, and autonomous systems—there are many smaller industry clusters that come together in around these areas. This appendix identifies eleven more narrow clusters that were used to analyze Pittsburgh’s innovation economy and to develop the recommendations. Together, these eleven are considered Pittsburgh’s “advanced clusters” or advanced industries.

An industry cluster is a group of firms, related economic actors, and institutions that are located near one another

“Clusters are a striking feature of virtually every national, regional, state, and even metropolitan economy, especially in more economically advanced nations....Clusters are not unique; however, they are highly typical—and herein lies a paradox: the enduring competitive advantages in a global economy lie increasingly in local things—knowledge, relationships, motivation—that distant rivals cannot match.”

Michael Porter, “Clusters and the New Economics of Competition,” *Harvard Business Review*, November-December 1998.

and that draw productive advantage from their mutual proximity and connections.³⁹ The idea that state and regional development is driven by industry clusters of geographically localized concentrations of firms in related sectors that do business with each other and have common needs for trained workers, infrastructure, and technology goes back in the economic literature to the writings of Alfred Marshall in the late 19th and early 20th centuries.⁴⁰ But industry cluster development as a best practice for economic development has taken hold only in the past two decades, and its application has been primarily focused on enabling states and regions to compete in high-growth, innovation-led development.

There is no standard set of industry clusters for advanced industries that fits each region. The composition of clusters in Philadelphia would make little sense in Pittsburgh, for example. Instead, identifying regional advanced industry

clusters requires analyzing the specific local advanced industries that are focused on economic base activities and determining where there are logical connections and interrelationships in the regional economy.

Identifying the appropriate clusters within Pittsburgh’s economy involved a three-step process:

1. Advanced industries and advanced business and health industries in Pittsburgh were analyzed at the most detailed industry levels.⁴¹ to understand what industries stand as economic drivers based on size, relative concentration/specialization, and recent trends, particularly against national performance.
2. Clusters based on the inter-industry relationships of prominent advanced industries were constructed. Input/output models showing the purchases of goods or services between industries enabled the identification of industries that do business together. Data from IMPLAN, which relies on a widely used model that customizes likely supplier chain relationships based on the economic structure found in each state, informed the cluster analysis.
3. The data were complemented by an examination of the presence of large firms and their activities. Information from corporate databases and company websites was accessed to understand companies’ products, services, and applied technologies and where each fits relative to other industries in the state.

The analysis identified 11 distinct industry clusters driving Pittsburgh’s economy. Table A-1 summarizes the major industry components of these clusters and provides examples of leading firms found in Pittsburgh.

Table A-1: Eleven distinct industry clusters driving Pittsburgh’s economy

Industry cluster	Types of industry activities	2015 size in Pittsburgh region	Examples of leading companies
Automation and industrial machinery	Relay and industrial control manufacturing Industrial process instruments Measuring and controlling devices	6,909 jobs 118 establishments	Westinghouse; Sensus Metering Systems; Emerson; Industrial Scientific Corp.; Eaton
Chemicals, polymers, and other non-metal materials (“chemicals / polymers”)	Petroleum/coal-based chemical products Plastic materials and resin manufacturing Inorganic chemical manufacturing	13,177 jobs 266 establishments	Bayer; Axiall; Eastman Chemical; Carbide/ Graphite Group; Nova Chemicals
Computing, networking, information services, and internet applications (“computing”)	Custom computer programming Computer systems design Software publishing Data processing, hosting, and related services	17,474 jobs 1,138 establishments	Capgemini (iGate); HCL Global Systems; Nityo Infotech Corp; IBM; Google
Corporate services	Managing offices (i.e., headquarters) Administrative consulting services Human resource consulting Marketing consulting	47,596 jobs 1,733 establishments	Deloitte; Management Science Associates; AON Hewitt; Development Dimensions International
Electronics manufacturing	Switchgear Telephone equipment Wiring devices	5,928 jobs 94 establishments	Eaton; Mitsubishi Electric Power Products; Aerotech; Compunetix; Windurance
Energy	Natural gas extraction Nuclear power Electric power generation Electric power distribution	18,732 jobs 519 establishments	Consol; West Penn Power; Pennsylvania Transfer Technology; Pennzoil-Quaker; GE Power Conversion
Engineering, commercial research, and technical services (“engineering / technical services”)	Engineering services Testing laboratories Environmental consulting Physical and biological research	29,766 jobs 1,680 establishments	Bechtel; Thermo Fisher Scientific; Disney Research

Industry cluster	Types of industry activities	2015 size in Pittsburgh region	Examples of leading companies
Finance and insurance services	Commercial banking Health insurance provider Property and casualty insurer Portfolio management	54,691 jobs 3,481 establishments	PNC; Servicelink; Highmark; Chicago Title Insurance; HM Insurance Group
Health services	General medical and surgical hospitals Diagnostic imaging centers Blood and organ banks	93,601 jobs 1,446 establishments	UPMC; Allegheny General
Medical technology products	Electromedical devices Surgical and medical instruments Medical laboratories	8,809 jobs 321 establishments	Phillips Respironics; Zoll Services; Thermo Fischer Scientific; Berkley Medical
Metals & metal processing	Iron and steel mills Ferroalloy products Copper foundries Railroad rolling stock mfg.	29,276 jobs 795 establishments	US Steel; Gupta Permold; Duraloy Technologies

Performance of Pittsburgh's innovation-leading drivers

Pittsburgh's 11 advanced industry clusters represent key drivers of economic activity and employment in the region. With 326,000 jobs in 2015, these 11 clusters represent one-third of private-sector employment in the region. From 2009, the beginning of the economic recovery, through 2015, the job growth of these clusters nearly doubled that of the overall private sector in Pittsburgh—8.4 percent versus 4.4 percent. Six out of 10 new jobs added to the Pittsburgh economy have been generated from these 11 advanced industry clusters.

While the generation of jobs is an important measure

of success, many other measures of the economic performance of the advanced industry clusters need to be considered. A comprehensive set of performance measures for each of the advanced industry clusters include:

- Relative concentration in the local economy compared to the nation;
- Job generation;
- Relative growth compared to the nation;
- Relative productivity levels compared to the nation;
- Average wages;
- Economic multiplier impacts on the Pittsburgh economy.

Defining the key measures of advanced industry performance for Pittsburgh

Relative concentration—a measure of how specialized an advanced industry is in Pittsburgh relative to the nation, or a gauge of the “competitive advantage” for the advanced cluster in Pittsburgh. The specific measurement of relative concentration is known as a location quotient, the share of Pittsburgh’s employment found in a particular advanced cluster divided by the share of total industry employment in that advanced cluster for the nation. A location quotient that is substantially above the national average is considered “specialized.”

Job generation—a straightforward measure of whether an advanced cluster has been gaining or losing jobs in Pittsburgh.

Relative growth—a measure of whether a local advanced cluster is gaining or losing competitive share compared to the nation. It is the difference between the percentage change in employment in an advanced cluster in Pittsburgh minus the percentage change in employment in that same advanced cluster for the nation.

Productivity —a measure of the economic output generated by each job. Comparing the level of productivity of Pittsburgh’s advanced cluster to the national level informs whether the Pittsburgh advanced cluster is better able to make use of advances to produce goods and services and is able to produce more complex, higher-value products.

Average wages—a reflection of the overall quality of jobs found within an advanced cluster. It is a measure that relates the contribution of the cluster to Pittsburgh’s per capita income and ultimately to the economic well-being of the state. By comparing average wage levels across advanced clusters, it is possible to learn which industries offer high-quality jobs.

Economic multiplier—a measure of the broader economic impact of each cluster’s economic activity on the local economy. Of importance for economic development is how inter-connected an advanced cluster is to the regional economy.

Relative concentration of the advanced clusters

In regional economic analysis, a common metric of specialization is a *location quotient*, the share of a local area’s employment found in a particular cluster divided by the national share of industry employment in that cluster. A location quotient greater than 1.0 indicates a higher relative concentration, whereas a location quotient of less than 1.0 signifies a relative underrepresentation. A location quotient approaching 1.20 denotes employment concentration significantly above the national average and indicates specialization.

Nine of Pittsburgh’s 11 advanced industry clusters stand as specialized industries (see Table A-2), an impressive level of specialization given the city’s industrial diversity spanning manufacturing, technical services, health services, and finance and insurance. Together, the 11 advanced industry clusters are 33 percent more concentrated in Pittsburgh than in the nation.

Given Pittsburgh’s rich manufacturing legacy, it is not surprising that all the traditional advanced manufacturing

clusters in the region are highly specialized. The most specialized include automation and industrial machinery and metals & metal processing, with each having more than two times the national employment concentration. The advanced industry cluster of engineering/technical services is 46 percent more concentrated than the nation, suggesting that Pittsburgh's manufacturing base is competing on the basis of innovation. This emphasis on technology services foreshadows the strength of advanced manufacturing in productivity levels, as discussed below.

Other large advanced business and health service industries also stand out as industry specializations and point to the diversification of the region's economy. Corporate services, largely reflecting the presence of

headquarter operations, is 45 percent more concentrated in Pittsburgh than in the nation. Health services is not far behind at 33 percent more concentrated, which is remarkable since health care is traditionally viewed as a sheltered industry that nearly all regions require to serve local needs. In Pittsburgh, this high level of specialization points to a clinical excellence in health care that attracts patients from well beyond the region. The finance and insurance cluster is 15 percent more concentrated in Pittsburgh than in the nation, but with 55,000 employees it towers over more traditional manufacturing industries as an economic driver for the region.

The two advanced clusters in Pittsburgh that are lagging in national industry specialization are computing and

Table A-2: Relative concentration of Pittsburgh's 11 advanced clusters compared to U.S. overall

Advanced cluster	Degree of specialization (location quotient), 2015
Automation and industrial machinery	2.61
Metals and metal processing	2.09
Chemicals/polymers	1.83
Engineering/technical services	1.46
Corporate services	1.45
Energy	1.42
Health services	1.33
Electronics manufacturing	1.26
Finance and insurance	1.15
Medical technology	0.97
Computing	0.73
Pittsburgh advanced clusters	1.33
Pittsburgh total private sector	1.00

Source: IMPLAN and QCEW.

medical technology, a pattern that raises concerns about the disconnect of industry and university strengths. The medical technology industry cluster is 3 percent lower in concentration than nationally and the computing industry cluster is 27 percent lower, surprising levels given the outstanding research strength of Carnegie Mellon University in computer science, where it typically ranks as the best in the nation, and the strength of the University of Pittsburgh and UPMC in academic medical research. This disconnect between industry and university specializations is of great concern and suggests areas for improvement to advance Pittsburgh's innovation economy and the economic success of the region.

Job generation by the advanced clusters

Job generation is one of the primary measures of whether an industry is growing or declining, and for the economy as a whole it is a key measure of economic growth. This assessment considers the 2009 to 2015 period, since those years show the change in jobs since the beginning of the current economic recovery through the most recent year of available data.

In job generation, nine of the 11 advanced clusters have grown, one has remained flat (metals and metal processing), and one has declined (electronics manufacturing). Overall, the 11 advanced clusters grew

Table A-3: Job generation from 2009-2015, percentage change for Pittsburgh's 11 advanced clusters

Advanced cluster	Percentage employment growth, 2009-2015
Computing	46.4%
Energy	32.7%
Corporate services	18.5%
Engineering/technical services	18.3%
Chemicals/polymers	10.4%
Automation and industrial machinery	6.3%
Finance and insurance	1.8%
Medical technology	1.1%
Health services	0.8%
Metals and metal processing	-0.4%
Electronics manufacturing	-4.0%
Pittsburgh advanced clusters	8.4%
Pittsburgh total private sector	4.4%

Source: IMPLAN QCEW.

by 8.4 percent, well outpacing the 4.4 percent growth of Pittsburgh's private-sector industries overall (see Table A-3).

Computing is the fastest-growing advanced cluster, with job growth of 46.4 percent from 2009 to 2015, albeit from a low base, suggesting that Pittsburgh may be turning a corner on this industry that has had a low industry specialization despite strong university research presence. The other lagging advanced cluster in industry specialization, medical technology, has not had the same success, but it is growing at a low 1.1 percent.

Despite the flat to declining growth in metals and electronics clusters, other advanced manufacturing clusters are making sizable gains, led by energy (32.7 percent), chemicals/polymers (10.4 percent), and automation and industry machinery (6.3 percent)

Among the services-oriented advanced industries, both corporate services and engineering/technical services are growing robustly, each advancing by more than 18 percent from 2009 to 2015. Health services, however, similar to medical technology, is advancing at a low rate, 0.8 percent.

Table A-4: Relative growth of employment in Pittsburgh's 11 advanced clusters, 2009–2015, compared to U.S. overall

Advanced cluster	Pittsburgh's relative employment growth compared to U.S., 2009 – 15 (percentage point difference)
Energy	16.8
Computing	16.1
Engineering/technical services	7.1
Chemicals/polymers	3.2
Electronics manufacturing	1.2
Automation and industrial machinery	-1.6
Finance and insurance	-2.0
Corporate services	-2.7
Medical technology	-4.9
Health services	-5.4
Metals and metal processing	-12.8
Pittsburgh advanced clusters	-2.6
Pittsburgh total private sector	-6.0

Source: IMPLAN QCEW.

Relative employment growth of the advanced clusters

In considering how an advanced industry cluster is performing, it is important to assess whether it is gaining or losing market share compared to that cluster at the national level. It may be that an advanced cluster is gaining jobs but still not keeping pace with national growth and so losing market share. Alternatively, an advanced cluster declining in jobs locally may be performing better than the nation and so gaining in competitive share, suggesting more resilience than the nation overall.

The relative employment growth of the advanced clusters considers the differences between the percentage change in employment for Pittsburgh minus the percentage in employment in that same cluster for the nation. The period 2009 to 2015 is used to view how the industry has recovered since the Great Recession.

All the advanced clusters found in Pittsburgh grew nationally from 2009 to 2015, except for electronics manufacturing, which declined (see Table A-4). This broad base of growth reflects the fact that the national recovery underway is widely shared among advanced industries.

Relative to the average national job growth from 2009 to 2015, Pittsburgh's advanced clusters have had a mixed performance, with just five of the 11 advanced clusters outpacing national employment trends. Most impressive, however, is that the energy and computing clusters each outpaced national growth by more than 16 percentage points. Engineering/technical services also grew much faster than the nation, at 7.1 percentage points higher, while chemicals/polymers and electronics manufacturing slightly outpaced the nation.

More generally, however, the 11 advanced clusters were slightly off the pace of the nation, growing 2.6 percentage points slower in Pittsburgh. This decline still outperformed the overall economy of Pittsburgh, which across all private-sector industries grew 6 percentage points less than the nation. The slower growth of both advanced clusters and private-sector industries in Pittsburgh points to the continued economic headwinds that the city is confronting.

Productivity of the advanced cluster

Advanced economic development is more than just promoting the growth of startup companies that are commercializing new technologies. Just as critical, if not as widely heralded, is the ability of industry to put technology to work. To assess Pittsburgh's competitive position in technology deployment, Brookings and TEconomy analyzed output per worker to compare Pittsburgh's overall economy and advanced clusters to national levels of productivity. Higher output per worker compared to the nation suggests more effective deployment of technologies in production as well as an ability to produce more complex, higher-value products. Value-added per employee is calculated from data on employment and output reported for industries in Pittsburgh and the United States by IMPLAN.

Pittsburgh has a mixed performance among its advanced clusters in productivity levels compared to the nation (see Table A-5). On the positive side, nearly all the manufacturing clusters in Pittsburgh stand higher than the nation, with the exception of electronics manufacturing. This strong showing suggests the continued competitiveness of the region in manufacturing.

Corporate services is the only advanced cluster outside of manufacturing that has a higher productivity level than the nation. Several other advanced clusters are not far off national productivity, including engineering/technical services, health services, and computing. Advanced clusters well below the national average are finance and insurance, medical technology, and electronics manufacturing.

Overall, the 11 advanced industry clusters have a slightly higher level of productivity than the nation, while all private-sector industries in Pittsburgh are slightly lower than the nation. The differences compared to the nation are small, which suggests that productivity is best viewed on an industry cluster-by-cluster basis.

Table A-5: Relative productivity of Pittsburgh’s 11 advanced clusters, compared to U.S. overall

Advanced cluster	Pittsburgh’s relative productivity compared to U.S., 2015
Corporate services	127%
Energy	119%
Metals and metal processing	119%
Chemicals/polymers	108%
Automation & industrial machinery	106%
Engineering/technical services	99%
Health services	93%
Computing	90%
Finance and insurance	82%
Electronics manufacturing	57%
Medical technology	57%
Pittsburgh advanced clusters	103%
Pittsburgh total private sector	98%

Source: IMPLAN.

Average wages in the advanced clusters

Economic development focuses not just on jobs but on the quality of jobs, and the average wages paid by each cluster are an important measure of the quality of the jobs created. As presented in Table A-6, the average wage across Pittsburgh’s 11 advanced clusters is well above the overall average wage for the region. All of the advanced clusters, except for health services, have an average wage above the regional average. This performance demonstrates the importance of these advanced clusters for creating high-quality jobs that can raise overall standards of living and promote economic prosperity.

Compared to the national levels of average wages, though,

the advanced clusters generally fall short. Across all advanced clusters, Pittsburgh stands at 92 percent of the national average wage, a level on par with the lower cost of living in Pittsburgh. However, overall average wages in Pittsburgh are at the national average. Two advanced clusters in Pittsburgh that stand out with higher wages than advanced clusters nationally are corporate services and metals & metal processing, each of which have much higher productivity than the nation. The other clusters with higher productivity in Pittsburgh than the nation are close to the U.S. average wages. The clusters well off the U.S. level of productivity generally have much lower wages compared to the United States overall.

Table A-6: Average wages for Pittsburgh’s 11 advanced clusters, level and percentage of U.S. average wages, 2015

Advanced cluster	Pittsburgh	Percentages of U.S. average wages, 2015
Corporate services	\$126,131	120%
Energy	\$96,042	98%
Computing	\$95,367	83%
Engineering/technical services	\$86,227	94%
Finance and insurance	\$79,745	81%
Medical technology	\$71,319	69%
Automation and industrial machinery	\$70,590	98%
Electronics manufacturing	\$68,723	72%
Metals & metal processing	\$60,906	110%
Chemicals/polymers	\$59,416	98%
Health services	\$46,739	93%
Pittsburgh advanced clusters	\$76,270	92%
Pittsburgh total private sector	\$52,829	100%

Source: IMPLAN.

Economic multiplier of the advanced clusters

It is important to consider the broad impact of each industry on the region’s economy, and one way to do this is to analyze the economic impact from a \$1 million increase in economic activity or output. This was accomplished using the IMPLAN input-output model for the Pittsburgh region, a tool that estimates inter-industry purchasing (indirect multiplier) and income effects from personal consumption of increased wages paid (induced multiplier) in the region.

Indirect multipliers estimate the local economic activity generated from the purchase of goods and services up and down the supply chain to support the production of the industry being analyzed. This is a measure of the local

supply chain impact of the industry. The strength of indirect impacts is influenced by the strength and capacity of local suppliers to meet the input needs of a business. The larger and more diverse the local economy and the stronger the local supply chain, the higher the indirect impacts will be.

Additional economic impacts from an increase in economic activity occur through the wages paid to workers that are re-circulated through the regional economy as the wage earners make their own purchases. These are known as induced multipliers.

As shown in Table A-7, the highest total impact of a \$1

million increase in economic output is generated by clusters representing largely services industries, including engineering/technical services, finance and insurance, corporate services, and health services. Part of this impact is due to the induced impact of wages paid, which is expected due to higher wages paid and the larger share that wages compose of output.

What is surprising is that for several of these service-oriented advanced clusters the indirect impact from inter-industry purchasing is higher than for advanced clusters in manufacturing. For instance, engineering/technical services and finance & insurance exceed the indirect impact for all manufacturing industries. While manufacturing

usually has a stronger regional supply chain than services, this is not the case for Pittsburgh.

Further analysis suggests that the advanced manufacturing industries in Pittsburgh tend to have fewer supplier relationships and are more internally integrated. As shown in Figure A-1, Pittsburgh's manufacturing clusters have higher levels of internal capacity within each cluster that offsets the need for broader purchasing across supplier-based services and goods compared to the U.S. average. Thinner regional supplier networks limits the broader regional industry impacts of growth in these manufacturing industries, and suggests that as manufacturing has evolved in Pittsburgh the industry clusters have become more

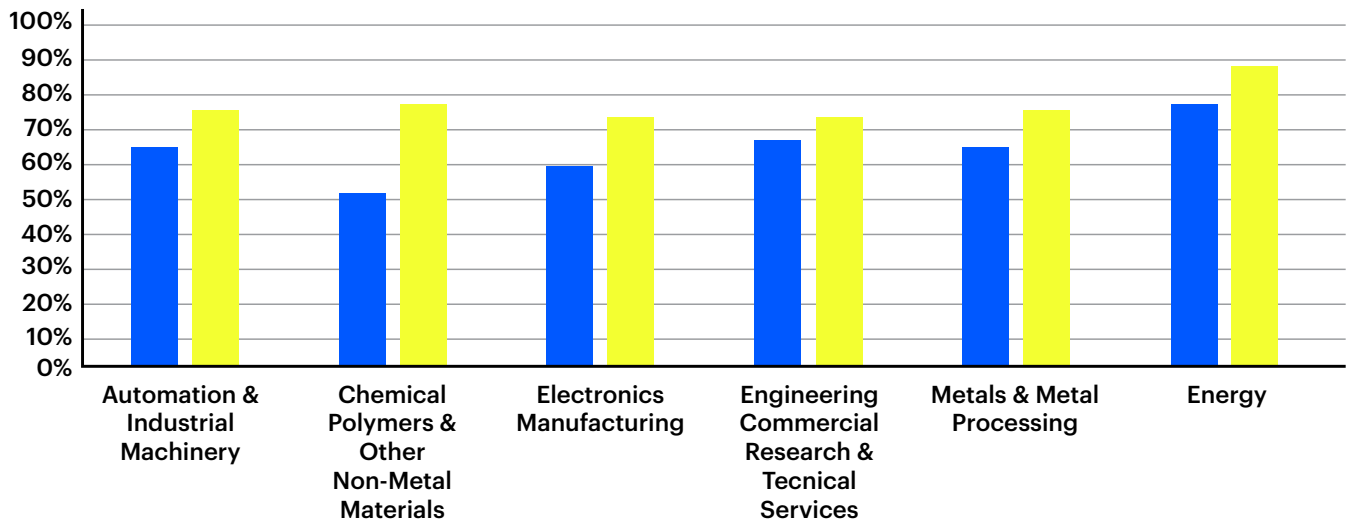
Table A-7: Output multipliers for Pittsburgh's 11 advanced clusters, impact per \$1 million increase in economic activity

Advanced cluster	Indirect impact (\$ millions)	Induced impact (\$ millions)	Total indirect and induced impact (\$ millions)
Engineering, commercial research, and technical Services	\$0.514	\$0.599	\$1.113
Financial and insurance	0.606	0.492	1.098
Corporate services	0.360	0.591	0.950
Health services	0.393	0.554	0.947
Computing, networking, information services and internet applications	0.421	0.443	0.864
Medical technology	0.440	0.372	0.811
Energy	0.409	0.334	0.743
Electronics manufacturing	0.383	0.294	0.677
Automation and industrial machinery	0.358	0.319	0.677
Metals and metal processing	0.407	0.263	0.670
Chemicals, polymers, and other non-metal materials	0.338	0.217	0.556

Source: IMPLAN.

Figure A-1: Percentage of industry supplier input mix contained within cluster, for selected manufacturing clusters, Pittsburgh compared to the U.S. average

■ US Economy
■ Pittsburgh Region



Source: U.S. Census Bureau, American Community Survey, authors' calculations.

vertically integrated and draw on fewer suppliers.

Additional analysis also finds that Pittsburgh's manufacturers are drawing upon the services of the computing cluster at 75 percent of the level that manufacturers are nationally. This points to continued opportunities to deepen the supply chain and broaden economic impacts of manufacturing in the region.

Summary and conclusion on the performance of Pittsburgh's advanced clusters

The advanced industry clusters identified in Pittsburgh are important drivers of economic growth in the region. Since the economic recovery, these clusters have experienced nearly twice the overall job growth of the region—8.4 percent compared to 4.4 percent for all private-sector industries. The jobs added by the growth of advanced clusters are high-quality jobs, with average wages more than \$22,000, or 44 percent, higher than the average for all private-sector jobs in Pittsburgh.

Despite the importance of these advanced clusters for the Pittsburgh economy, their performance relative to the nation is mixed. Job gains by the advanced industry clusters

since the recession have been healthy, but the clusters are lagging behind the United States overall by 2.6 percentage points. In average wages, Pittsburgh receives only 92 percent of the U.S. average across the 11 advanced clusters.

One bright spot is that productivity, a critical measure of the economic competitiveness of the region's industries, is higher on average within the advanced clusters in Pittsburgh than it is nationwide. A closer examination, however, finds that only manufacturing industries stand above the nation, and other advanced clusters, including computing, medical technology, and finance and insurance are lagging.

Similarly, the advanced clusters in Pittsburgh employ 33 percent more workers than expected given the size of the overall economy, implying that these clusters represent clear areas of specialization. But two advanced clusters, computing and medical technology, that lag the U.S. level of employment concentration represent world-class research strengths engendered by Pittsburgh's universities, and the fact that they lag suggests a significant disconnect between regional industry growth and regional research strengths.

A summary of how each of the advanced clusters is faring

across the six economic performance indicators is set out below. Nearly all the advanced clusters stand out in at least two of the indicators, with several high-to-strong performers and a couple of advanced clusters generally lagging in their performance.

- **High-performing clusters:** Engineering/technical services and energy clusters stand out in not having any weak performances across the six economic performance indicators.
- **Strong-performing clusters:** Corporate services and chemicals/polymers clusters have only one weak performance across the six indicators.
- **Moderate-performing clusters:** Five of the advanced clusters have strong performances in at least two of the indicators, including metals & metal processing, health services, finance & insurance, computing, and

automation & industrial machinery.

- **Weak-performing clusters:** Medical technology and electronics manufacturing have weak performance in four of the six indicators.

Looking forward, the breadth and diversity of Pittsburgh's advanced clusters suggest that they can be strong drivers of regional growth in the years to come. Among the region's priorities for ensuring that this potential can be realized is, first, addressing the disconnects identified in the analysis, including between the region's research strengths and industry development in computing and medical technology, and, second, better integrating the region's manufacturing base with other industries in the region, including computing.

Table A-8: Summary of Pittsburgh's advanced industry clusters' position relative to the U.S.

Technology cluster	Relative concentration 2015	Job generation 2009-15	Relative growth 2009-15	Relative productivity 2014	Relative average wages 2015	Output
Automation & industrial machinery	▲	■	▼	▲	■	▼
Chemicals/polymers	▲	▲	■	▲	■	▼
Computing	▼	▲	▲	■	▼	■
Corporate services	▲	▲	▼	▲	▲	▲
Electronics manufacturing	▲	▼	■	▼	▼	▼
Energy	▲	▲	▲	▲	■	■
Engineering/technical services	▲	▲	▲	■	■	▲
Finance & insurance	▲	■	▼	▼	▼	▲
Health services	▲	■	▼	■	■	▲
Medical technology	■	▼	▼	▼	▼	■
Metals & metal processing	▲	▲	▼	▲	▲	▼
Strong performance: ▲	LQ > 1.2	> 10%	> 5%	> Nation	> Nation	>\$900k
Moderate performance: ■	LQ .8 - 1.2	0% - 10%	0% - 5%	90% - 100% of Nation	90% - 100% of Nation	\$750k-\$900k
Weak performance: ▼	LQ < .8	Negative	Negative	< 90% of Nation	< 90% of Nation	>\$750k

Table A-9: List of advanced industries

NAICS code	NAICS title
Advanced Industries—Brookings Institution definition	
2111	Oil and gas extraction
2122	Metal ore mining
2211	Power generation and supply
3241	Petroleum and coal products manufacturing
3251	Basic chemical manufacturing
3252	Resin, rubber, and artificial fibers mfg.
3253	Agricultural chemical manufacturing
3254	Pharmaceutical and medicine manufacturing
3259	Other chemical product and preparation mfg.
3271	Clay product and refractory manufacturing
3279	Other nonmetallic mineral products
3311	Iron and steel mills and ferroalloy mfg.
3313	Alumina and aluminum production
3315	Foundries
3331	Ag., construction, and mining machinery mfg.
3332	Industrial machinery manufacturing
3333	Commercial and service industry machinery
3336	Turbine and power transmission equipment mfg.
3339	Other general purpose machinery manufacturing
3341	Computer and peripheral equipment mfg.
3342	Communications equipment manufacturing
3343	Audio and video equipment manufacturing
3344	Semiconductor and electronic component mfg.
3345	Electronic instrument manufacturing
3346	Magnetic media manufacturing and reproducing
3351	Electric lighting equipment manufacturing
3352	Household appliance manufacturing
3353	Electrical equipment manufacturing
3359	Other electrical equipment and component mfg.
3361	Motor vehicle manufacturing
3362	Motor vehicle body and trailer manufacturing
3363	Motor vehicle parts manufacturing
3364	Aerospace product and parts manufacturing
3365	Railroad rolling stock manufacturing
3366	Ship and boat building
3369	Other transportation equipment manufacturing
3391	Medical equipment and supplies manufacturing

NAICS code	NAICS title
3399	Other miscellaneous manufacturing
5112	Software publishers
5152	Cable and other subscription programming
5172	Wireless telecommunications carriers
5174	Satellite telecommunications
5179	Other telecommunications
5182	Data processing, hosting and related services
5191	Other information services
5413	Architectural and engineering services
5415	Computer systems design and related services
5416	Management and technical consulting services
5417	Scientific research and development services
6215	Medical and diagnostic laboratories
Advanced business & health services	
5221	Depository credit intermediation
5222	Nondepository credit intermediation
5223	Activities related to credit intermediation
5231	Securities and commodity contracts brokerage
5239	Other financial investment activities
5241	Insurance carriers
5242	Insurance agencies and brokerages
5251	Insurance and employee benefit funds
5259	Other investment pools and funds
5411	Legal services
5412	Accounting and bookkeeping services
5414	Specialized design services
5418	Advertising, PR, and related services
5419	Other professional and technical services
5511	Management of companies and enterprises
5611	Office administrative services
5614	Business support services
6214	Outpatient care centers
6216	Home health care services
6219	Other ambulatory health care services
6221	General medical and surgical hospitals
6222	Psychiatric and substance abuse hospitals
6223	Other hospitals
6231	Nursing care facilities
6232	Residential mental health facilities