

*The
Jefferson
Essays*

ERIE'S ADVANCED
INDUSTRIES

Jim Wertz, Ph.D.
Perry Wood, M.S.

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Ferki Ferati, M.A., Editorial Board
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ERIE'S ADVANCED INDUSTRIES

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This Jefferson Essay represents what we hope will be the beginning of a conversation about the strength of Erie's legacy firms in addition to its evolution into innovative, technology-driven firms which see only a bright horizon as they build on the shores of Lake Erie. Erie's advanced industries are strong and growing. But only through the nurturing commitments of policymakers, administrators and executives will Erie's advanced industries continue to thrive in support of our community

INTRODUCTION

There are many ways to package Erie's past, contextualize its present, and imagine its future. Erie's recent history, defined in the parlance of the Rust Belt, has become its sole identity, for better and worse. Like so many cities that lost thousands of manufacturing jobs in the 1980s and 1990s, Erie has struggled to find itself amid the landscape of emerging technologies and the technology boom of the early 21st Century. Economic development is at the core of urban strategies to maintain course and reach for a more stable future. But what is economic development? It is a term bandied about by politicians, civic groups, agencies, and universities, but its primary thrust is disparate and opaque. Most definitions agree on two key factors: job creation and the ability of people in the Erie region to get those jobs. After all, jobs, skills, and training are byproducts of the economic development process, not the variables that drive such processes.

In this essay, we examine the state of Erie's advanced industries - the key to Erie's future economic growth. Advanced industries invest deeply in research and development as they nurture and procure skilled labor capable of innovating and adapting to the needs and demands of global market forces and industrial change. There are 50 advanced industries in the United States, 27 of which are represented within the Erie economy. According to the Brookings Institution's study *America's Advanced Industries*, "U.S. advanced industries generate a large and rising share of the nation's GDP and, after years of decline, have led

the post-recession employment recovery.” In 2013, advanced industries employed 12.3 million workers nationwide – just 9 percent of the American workforce – but these industries contributed 17 percent of U.S. gross domestic product (GDP).

For Erie County, advanced industries are the manufacturing and information-driven firms that create products, intellectual property, and services that have a strong local foothold, a significant national identity, and in some cases a powerful international presence. GE Transportation comes to mind because it is the County’s largest employer, but there are hundreds of firms working along the 12th Street industrial corridor and in suburban business parks, tucked away beside the railroad tracks, or hidden down a dirt road that produce goods traded on the global exchange, although they seldom achieve a level of notoriety. Advanced industries not only are the largest source of income to the Erie region, they are the second largest source of jobs, providing the salaries, wages, and benefits that far outpace that of other sectors in the Erie economy.

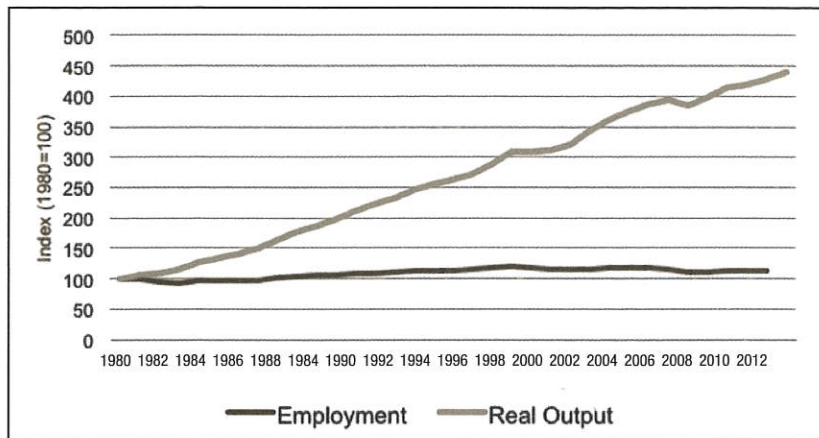
Erie’s advanced industries should be considered the cornerstone of Erie’s post-recession economy. While these industries represent a minority of the region’s hard assets, the output produced by these businesses rivals and, in many cases, outperforms the national average. Many of Erie’s advanced industries are engaged in strong trade sectors, which means that the products created in Erie have an international market and the revenue accumulated from such production

returns to the local economy. These industries also offer a framework for the future of education and public-private partnerships within the region. As vocational schools, colleges, and universities diversify their academic offerings, their curriculum should align with both the short-term needs and the long-term objectives of Erie’s advanced industries. Investment in advanced industries should be a collective effort that marshals public and private resources to foster economic growth and advance social progress throughout the region.

THE STATE OF ERIE ECONOMY

Erie has experienced a precipitous decline in manufacturing during the past forty years. Its shores are no longer lined with smokestacks, and old industrial corridors are primarily populated by myriad mixed-use enterprises. Such changes led many policymakers and the members of the general public to conclude that the region has suffered irreparable harm to its economy and the communities that comprise the region. While it is true that Erie's economy has not kept pace with national economic trends, total real output in Erie County has grown modestly but continuously since 1980, and total employment in the region has also grown by 16,000 jobs between 1980 and 2000.

Employment and Output Growth for Erie, MSA 1980-2013

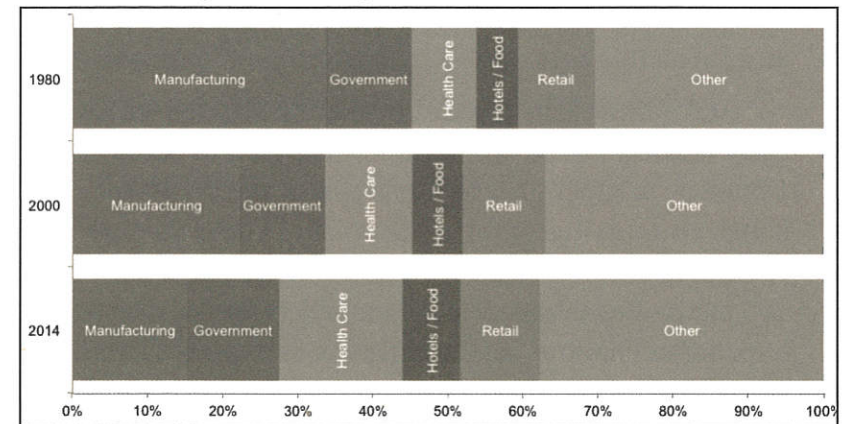


Source: Brookings Institution Analysis of Moody's Analytics Data

Erie continues to rebound from the economic recession of the mid-2000s, demonstrating resilience

and the potential for long-term growth. The story of industry in Erie is one of pliable economic boundaries and industrial labor that has moved away from traditional manufacturing sectors in favor of industries related to health care and service industries.

Erie MSA Employment Share by Select Major Sectors, 1980-2013



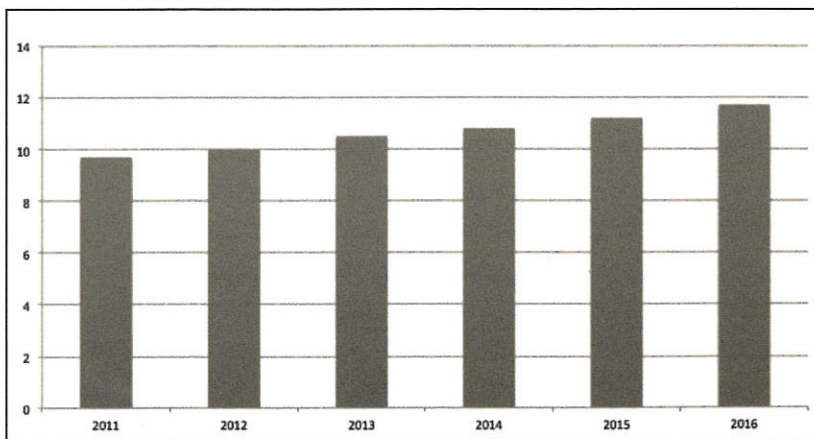
Source: Brookings Institution Analysis of Moody's Analytics Data

While Erie lost nearly 10 percent of its total employment during the 1950s and 15 percent of its workforce in the early 1980s, employment in Erie County rose to an all-time high of nearly 138,000 in 2000, according to a study by the Economic Research Institute of Erie. Manufacturing in Erie County has been replaced as the top local industry over the course of the past four decades as health care and non-manufacturing industries, like retail, leisure, and professional business services, filled the void left by the scaling down of traditional manufacturing, such as machinery, transportation equipment, and furniture production.

During the recession between 2007 and 2010, the Erie region lost 6,700 jobs, of which 68 percent came from manufacturing. Since the end of the last recession, however, more than 2,500 manufacturing jobs were created, marking the first increase in the number of local manufacturing jobs in decades. But despite modest gains in manufacturing, the region remains more than 4,000 jobs short of its pre-recession employment levels.

According to the U.S. Conference of Mayors, which estimates a Gross Metro Product, analogous to Gross Domestic product for a country, Erie ranked 9th out of sixteen metros in Pennsylvania in 2014 and fell below the 50th percentile nationally, ranking 188th out of 363 metro areas. As the U.S. economy continues to expand and national unemployment is expected to fall below 4 percent, Erie's economy is expected to have better than 1.5 percent growth while unemployment is expected to shrink below 5.3 percent by 2016.

Erie MSA Gross Metro Product, 2011-2016 (U.S.\$ Billions)



Source: U.S. Conference of Mayor's, U.S. Metro Economies: GMP and Employment 2014-2016.

Today, health care and social assistance agencies comprise more than 16 percent of employment in Erie, making it the largest sector in the region represented by 15 of the top 50 employers in the region. Education services (including K-12 and colleges) and government (city, county, state, and federal) together account for 13 of the top 50 employers in the MSA*, with retail firms and staffing services round out the majority of non-manufacturing jobs in Erie County. Erie employment rates in all of these categories exceed the national average with the exception of government employment (11.5 percent), which is 2.3 percent below the national average.

At its peak in 1950, manufacturing was responsible for nearly 50,000 jobs in the Erie economy. By the end of the last recession in 2010, manufacturing employment fell to approximately 20,000. Nevertheless, manufacturing remains the second largest employment sector in Erie while boasting more than 23 percent of the county's industrial income, placing Erie's income from manufacturing at more than twice the national average. This is perhaps the most important note with regard to Erie's economic future, because manufacturing holds the greatest promise in terms of wages and the multiplier effect of those wages throughout the community. "I think that all places that have had a manufacturing

*Metropolitan statistical areas (MSA) are geographic entities delineated by the Office of Management and Budget (OMB) for use by Federal statistical agencies in collecting, tabulating, and publishing Federal statistics. A metro area contains a core urban area of 50,000 or more population. Each metro area consists of one or more counties and includes the counties containing the core urban area, as well as any adjacent counties that have a high degree of social and economic integration (as measured by commuting to work) with the urban core.

past, particularly those that had an ecosystem of not just companies – but companies, universities, training facilities, private sector leadership – that ecosystem can be revived,” said Bruce Katz, director of the Brookings Institution Metropolitan Policy Program. “The U.S. seems poised for a manufacturing renaissance and places like Erie can participate in that, and already are, because of your location and legacy assets.” Although northwest Pennsylvania was wracked by several difficult decades of downsizing and industrial flight, Erie’s legacy manufacturing assets position the region for full participation in America’s advanced industries.

AMERICA’S ADVANCED INDUSTRIES

Advanced industries have led the post-recession recovery, outpacing non-skilled employment sectors and facilitating job creation outside of advanced industries. Advanced industries are those that meet two specific criteria. First, an industry must meet or exceed the 80th percentile for research and development spending per employee, requiring that an industry spend a minimum of \$450 per employee on research and development (R&D), which means that the resources invested in new technologies or processes that improve productivity or lead to the creation of a new products. R&D spending has significant spillover effects on industry and the local economy. Additionally, the share of workers in an industry whose jobs require a high degree of STEM knowledge must exceed 21 percent, the national average for such positions in American industry. The investment in

research and skilled labor places these industries at the forefront of innovation and productivity-enhancing technologies. Many of Erie’s industries already meet these criteria and many new industries are dependent upon ongoing research and development as well as STEM knowledge to be successful in their respective markets. Nationally, fifty industries meet these criteria: thirty-five in manufacturing, three in energy, and twelve in services.

While America’s advanced industries are leading the post-recession recovery, these industries comprise only 9 percent of the American workforce. Nevertheless, advanced industries produce \$2.7 trillion in annual output, accounting for an astonishing 17 percent of the U.S. GDP. In addition to the efficient productivity of U.S. advanced industries, the Brookings Institution concludes that these businesses employ 80 percent of the nation’s engineers, perform 90 percent of private sector research and development, generate 85 percent of American patents, and constitute 60 percent of American exports.

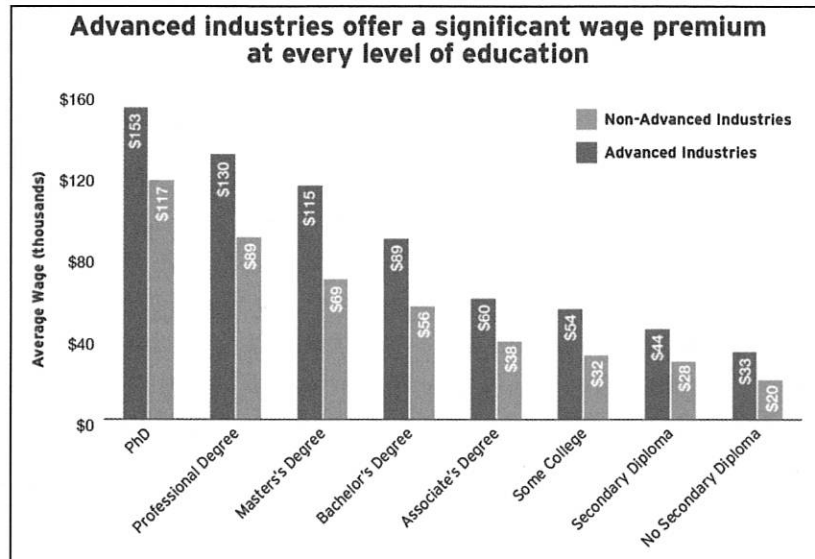
Moreover, in spite of the decentralization of supply chain networks, advanced industries are estimated to support more than 25 percent of the American workforce. Advanced industries purchase more than \$230,000 in goods and services per employee. By comparison, other industries purchase just \$67,000 worth of goods and services from other businesses. Domestically, advanced industry spending is responsible for the creation of 2.2 new jobs for every position created by an advanced industry employer.

The advanced industries sector is composed of 50 individual R&D- and STEM knowledge-intensive industries

4-Digit NAICS Code	Industry Title	Definitional Criteria		Summary Statistics	
		R&D Spending per Worker (2009)	Share of High STEM Knowledge Occupations (2012)	U.S. Employment (2013)	U.S. Output (2013) (thousands)
MANUFACTURING					
3241	Petroleum and Coal Products*	\$693	42%	111,200	\$80,186,100
3251	Basic Chemicals	\$14,879	50%	141,800	\$60,674,000
3252	Resins and Synthetic Rubbers, Fibers, and Filaments	\$11,110	46%	91,500	\$34,691,800
3253	Pesticides, Fertilizers, and Other Agr. Chemicals	\$33,109	43%	37,900	\$13,603,100
3254	Pharmaceuticals and Medicine	\$143,110	48%	277,100	\$141,516,200
3259	Other Chemical Products*	\$45,778	29%	82,300	\$25,104,500
3271	Clay Products	\$6,308	30%	39,300	\$3,885,300
3279	Other Nonmetallic Mineral Products	\$4,558	22%	70,300	\$7,317,600
3311	Iron, Steel, and Ferroalloys	\$2,705	29%	90,800	\$15,203,100
3313	Aluminum Production and Processing	\$4,329	32%	57,900	\$7,355,600
3315	Foundries	\$1,372	36%	128,600	\$13,991,200
3331	Agr., Construction, and Mining Machinery	\$11,709	39%	250,800	\$36,446,400
3332	Industrial Machinery	\$23,672	50%	107,000	\$15,796,400
3333	Commercial and Service Industry Machinery	\$13,330	42%	87,200	\$11,925,200
3336	Engines, Turbines, and Power Trans. Equipment	\$13,557	45%	97,900	\$14,842,400
3339	Other General Purpose Machinery	\$5,293	42%	254,800	\$32,757,200
3341	Computers and Peripheral Equipment	\$60,339	71%	158,800	\$60,734,100
3342	Communications Equipment	\$91,428	57%	102,400	\$25,696,000
3343	Audio and Video Equipment	\$28,074	32%	19,800	\$3,970,800
3344	Semiconductors and Other Electronic Components	\$49,612	50%	374,900	\$83,242,500
3345	Navigation, Measurement, and Control Instruments	\$14,265	58%	393,000	\$88,975,600
3346	Magnetic and Optical Media	\$5,919	28%	19,000	\$4,701,500
3351	Electric Lighting Equipment*	\$821	28%	47,300	\$6,166,800
3352	Household Appliances*	\$821	27%	57,600	\$7,174,300
3353	Electrical Equipment*	\$821	37%	144,200	\$20,628,800
3359	Other Electrical Equipment and Components*	\$821	37%	124,900	\$16,297,200
3361	Motor Vehicles	\$48,461	27%	178,100	\$41,639,800
3362	Motor Vehicle Bodies and Trailers	\$759	23%	134,100	\$17,079,200
3363	Motor Vehicle Parts	\$6,791	36%	508,000	\$79,621,800
3364	Aerospace Products and Parts	\$20,501	60%	492,500	\$96,230,000
3365	Railroad Rolling Stock	\$2,782	32%	25,200	\$3,641,600
3366	Ship and Boat Building	\$4,640	39%	134,300	\$17,139,100
3369	Other Transportation Equipment	\$13,476	30%	32,300	\$4,548,600
3391	Medical Equipment and Supplies	\$24,343	33%	306,700	\$49,965,200
3399	Other Miscellaneous	\$8,547	23%	273,000	\$33,273,900
ENERGY					
2111	Oil and Gas Extraction*	\$613	58%	197,700	\$212,280,600
2122	Metal Ore Mining	\$836	48%	44,500	\$19,094,400
2211	Electric Power Generation, Trans., and Distribution	\$2,173	47%	394,000	\$219,849,500
SERVICES					
5112	Software Publishers	\$80,977	70%	297,200	\$116,417,500
5152	Cable and Other Subscription Programming	\$1,370	36%	72,500	\$33,131,500
5172	Wireless Telecommunications Carriers	\$455	40%	155,300	\$49,110,500
5174	Satellite Telecommunications	\$5,048	69%	9,700	\$3,903,200
5179	Other Telecommunications	\$1,999	57%	84,300	\$32,904,700
5182	Data Processing and Hosting*	\$1,020	56%	267,500	\$45,588,500
5191	Other Information	\$27,476	40%	194,200	\$45,801,200
5413	Architecture and Engineering	\$738	74%	1,353,700	\$179,136,700
5415	Computer Systems Design	\$7,225	75%	1,698,400	\$246,466,900
5416	Mgmt., Scientific, and Technical Consulting	\$1,950	39%	1,177,100	\$166,593,900
5417	Scientific Research and Development	\$13,627	73%	635,700	\$112,426,700
6215	Medical and Diagnostic Laboratories	\$988	50%	241,100	\$21,434,000
Advanced Manufacturing Industries				6,449,900	\$1,175,724,700
Advanced Energy Industries				636,200	\$461,224,600
Advanced Services Industries				6,188,700	\$1,002,915,300
Advanced Industries Total				12,272,800	\$2,679,864,500

* = Imputed from 3-digit NAICS by Brookings
Sources: Brookings analysis of National Science Foundation, Bureau of Labor Statistics, and Moody's Analytics data

Brookings Institution, America's Advanced Industries (2015)



Brookings Institution, America's Advanced Industries (2015)

In contrast to the rest of the American economy, advanced industries offer employee wages and compensation that average \$90,000, nearly double the national average. This pattern is supported across advanced industries regardless of the education level of its employees. Even the least-educated advanced industry employee earns on average \$13,000 per year more than their counterparts employed in non-advanced industries. This is significant because more than half of the advanced industry workforce possess less than a bachelor's degree. Those who have earned a bachelor's degree earn on average \$33,000 per year more than non-advanced industry labor.

America's advanced industry super-sector is comprised of three primary sectors: Advanced manufacturing, advanced energy, and advanced

services. In 1980, manufacturing was the preponderant American industry. However, manufacturing shed 3 million net jobs between 1980 and 2013 as a result of technological and structural changes in the global economy. Today, it accounts for just 17 percent of American jobs even though it continues to employ 81 percent of the advanced industry workforce – 9.9 million jobs – while yielding higher wages and greater financial returns than its counterparts, accounting for 76 percent of total output by advanced industries. Pharmaceuticals and industries related to computing and software production lead manufacturing research and development nationally. These firms are also leading the U.S. as some of the largest employers in the advanced industries super-sector as well as the manufacturing sector, generally. Only the auto industry employs more advanced industry workers. Although manufacturing leads advanced industry output and employment, only those firms associated with computing, communication, and aerospace engineering have workforces in which more than half of employees hold STEM knowledge jobs. The remaining industries' share of STEM knowledge employees varies between 23 percent and 50 percent.

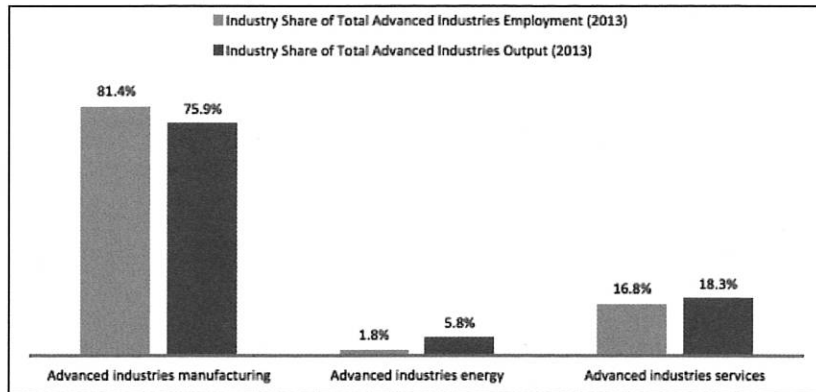
Likewise, the energy sector boasts a comparatively strong economic impact on advanced industries relative to its rather insignificant share of overall employment. With just 1.8 percent of the workforce represented in only three industries, firms in the energy sector contribute nearly 6 percent of the total output for advanced industries in the U.S. The success

of the energy sector in the post-recession recovery is due in part to the expansion of oil and gas drilling and innovations in technologies related to that sector's production, refinement, and distribution, which has led to large-scale expansion of employment, productivity, and profitability. Advanced energy firms employed more than 600,000 people in 2013 and produced more than half a trillion dollars in total output. On average, more than half of the employees of firms operating in oil and gas extraction, metal ore mining, and the generation, transmission, and distribution of electric power hold positions that require a high degree of STEM knowledge.

Services such as architecture, engineering, and computer software design, are the fastest growing portion of the super-sector. Just as service employment have absorbed non-advanced manufacturing and other industry workforce since 1980, so too have advanced services expanded as manufacturing within the sector has compressed. In that time, advanced services have an annual growth rate of 3.2 percent, nearly three times that of the U.S. economy. Even though advanced services now employ a majority of advanced industry labor, sector output trails manufacturing by more than \$120 million. As cloud computing and big data become increasingly valuable commodities, advanced industry services will continue to expand, which will carry with it a greater demand for workforce with high STEM and especially IT knowledge. Currently seven of the nation's twelve advanced service industries have STEM knowledge

jobs exceeding 50 percent of the labor pool. The ongoing digitization of the economy will only increase the demand for STEM and IT skillsets, both at the professional and community-college levels.

Advanced Industry Total Share of Employment and Output in U.S., 2013



Brookings Analysis of Moody's Analytics Data

Advanced industry employment is primarily concentrated in America's largest metropolitan regions. Eighty-five percent of the nation's 12.3 million advanced industry jobs belong to the country's largest metros. For example, 70 percent of petroleum engineers are employed in just three states: Texas, Oklahoma, and California; and, two MSAs – San Jose-Sunnyvale-Santa Clara, Calif. and Framingham, Mass. – have concentrations of systems software developers nearly ten times the national average, according to the U.S. Bureau of Labor Statistics. This is due in part to the diversity of firms and the density of supply chains that naturally occur amid large populations. In the nation's small and mid-sized metros, advanced industries tend to be concentrated around anchor institutions

in manufacturing or scientific research. The former are prevalent throughout the Midwest where metro economies were dominated by a few large enterprises, and the latter tend to be located near universities and laboratories that often focus on scientific or technological innovation.

Advanced industries represent less than 7 percent of employment on average in small and mid-sized metros. However, because of shared resources and specialized suppliers, firms within the sector carry with them myriad economic benefits within a region. "A competitive and growing advanced industries sector is prerequisite any future broadly shared prosperity," concluded the Brookings Institution report on America's advanced industries. "The nation should place a high priority on revitalizing them."

ERIE'S ADVANCED INDUSTRIES

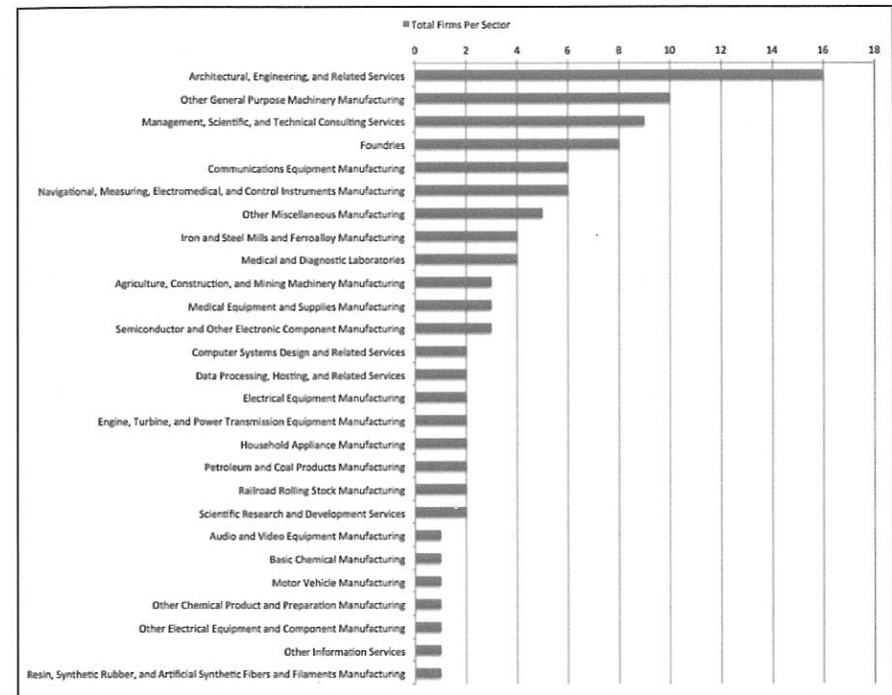
Revitalizing Erie's advanced industries will be no easy task. Sixty-eight percent of the jobs lost since the beginning of the 2007-2010 recession came in manufacturing. It was the continuation of a decades-long trend that plagues the region even as this essay is produced. The good news is that, like the national outlook for advanced industries, the wages and economic output of extant advanced industries in NWPA continued to grow, even as the number of jobs within the sector decreased and stagnated from more than 20,000 in 1980 to just more than 12,300 in 2013. Erie's advanced workforce earns nearly \$69,000 per year on average, while outside

this sector, wages average \$30,000 less per year. This trend illustrates the strength of advanced industries as well as the efficiency of their productivity, which results primarily from the adoption and expansion of new technologies within various industries. Despite troubling times, manufacturing still holds more than 80 percent of advanced industry jobs, nearly half of which are related to GE Transportation and Railroad Rolling Stock Manufacturing. The other beacon in Erie's advanced industries is the growth of advanced services, which accounts for 17 percent of local advanced industry and more than 18 percent of its total output. Among small metropolitan areas, Erie's advanced industries employment falls within the top 25 percent of the United States.

There are more than 800 firms in 27 advanced industries throughout the region. These firms can be categorized in numerous ways, but in terms of local employment and economic impact arranging them by the number of local firms within each industry allows us to think about long-term trends and the potential for growth within the advanced industries sector, generally. The following chart aligns the top 100 Erie firms with their respective industries. Manufacturing accounts for for 64 percent of Erie's 100 largest advanced industry firms, and advanced services hold a strong place in the regional landscape with 36 of the largest firms too. Although the employment and output pales in comparison to manufacturing, it is instructive to remember that jobs in advanced services tend to offer a greater density of STEM-educated

workers and the services offered tend to be reflective of the educational and occupational specialties within each firm. Architectural, engineering, and consulting firms lead advanced services.

Advanced Industry Sectors in Erie MSA, 2013



Erie's manufacturing portfolio is dominated by a single principal firm, without which the Erie economy would suffer significant harm. GE Transportation produces nearly \$1 Billion in annual sales and single-handedly accounts for more than half of Erie's advanced industry workforce. Just a few years ago, however, Fairview-based Spectrum Control and Spectrum Microwave collectively

employed nearly 3,000 people between the two firms and had combined annual sales of more than \$120 million. Spectrum Control developed, designed, and manufactured high-performance, custom solutions for the defense, aerospace, industrial, and medical industries worldwide, operating in four segments: Advanced Specialty Products, Microwave Components and Systems, Power Management Systems, and Sensors and Controls. Spectrum Microwave developed and produced radio frequency (RF) microwave components and systems. In 2011, these firms became wholly owned subsidiaries of API Technologies, based in Orlando, Fla. Today, the API/Spectrum workforce exists almost exclusively outside of northwest Pa, with just 145 positions retained in its former headquarters. Spectrum Control and Spectrum Microwave represented a bridge to Silicon Valley that many in the economic development community had touted as a necessary tether for the region's chain of fiscal sustainability. The companies' loss leaves the region in need of new ties to other innovative locales as it maintains the relationship with its single anchor institution, GE Transportation.

GE Transportation accounts for just 3 percent of the General Electric portfolio, but it remains an integral part of the Erie economy. GE Transportation moved its corporate headquarters to Chicago in 2012 after being housed for more than 100 years at its Lawrence Park facility on Erie's East Side. The transition of its corporate headquarters was coupled with the establishment of a \$96 million locomotive

production facility in Fort Worth, Texas that employs more than 500 people. Texas is a Right-To-Work state and the move was seen as a definitive challenge to the United Electrical Workers, the labor union that represents plant employees in Erie. GE announced its plan to construct its Texas facility as a result of a rise in locomotive orders, some of which were multiyear contracts. It did so after maximizing its existing resources. The company recalled approximately 800 workers in Erie following layoffs in 2009, and hired an additional 100 new employees after it exhausted its recall list. This pattern of layoffs and recalls was common but inefficient.

In 2011, GE concluded that it would shift overflow production from the Erie plant to other company facilities. However, after union negotiations failed at an aircraft engine plant in Lynn, Mass., where company officials had hoped to fill overflow orders, GE announced it would construct a new locomotive factory in Fort Worth to meet industrial demand. President & CEO of GE Oil & Gas Lorenzo Simonelli told the Fort Worth Star-Telegram, "We looked at various options, including Mexico, and selected Fort Worth." Starting salaries at the new plant were expected to be around \$17 per hour. Meanwhile, production continued in Erie at an unprecedented rate.

The support of its union labor force in managing costs, including wages, will be critical to the success of GE Transportation in the immediate future. Wages and benefits at the Erie facility, as well as the Fort Worth facility, are extremely competitive for both

union and non-union labor. "There are two things that create manufacturing jobs," GE Chairman and CEO Jeff Immelt told a group of Canadian politicians and customers in 2012. "One of them is super high-tech products like jet engines that we can manufacture very competitively anywhere in the world and particularly in North America. And the other is competitive wages."

Industries with >1000 Employees by Annual Sales (2013)

Company Name	Employees	Annual Sales (\$ Millions)	NAICS Title	Location
GE Transportation Systems	8000	914.2	Railroad Rolling Stock Manufacturing	Erie PA

Source: Brookings Analysis of Moody's Industry Data

The success of such anchor firms is critical to the future of Erie's advanced industries and the local economy, generally. GE Transportation, alone employs 6 percent of the active workforce in Erie County. Because Erie's industrial past is rooted in locomotive production at GE Transportation, the threat of outsourced labor and relocation of this firm, in particular, carries with it significant psychological repercussions in addition to the economic consequences attached to such a loss.

The success of major corporations in Erie only remains relevant if such success is bound to the expansion of smaller firms, some of which are inherently linked to major industry and some of which are independent of local supply chains. Many of the region's small and mid-size firms produce a greater annual output per employee than the major firms, an

indication of productivity and the ability to invest in R&D at levels exceeding major industry. For example, among firms with fewer than 1,000 employees, Eriez Manufacturing employs nearly 1,000 people with annual sales of nearly \$230 million, for an annual output per employee of just more than \$230,000. Erie Coke Corporation, on the other hand, employs 130 people with annual sales of just more than \$42 million, for an average annual output per employee of more than \$323,000.

Top 10 Industries (n=23) with 100-999 Employees by Annual Sales (2013)

Company Name	Employees	Annual Sales (\$ Millions)	NAICS Title	Location
Eriez Manufacturing Co.	980	229.53	Agriculture, Construction, and Mining Machinery Manufacturing	Erie PA
PHB, Inc.	700	55.5	Foundries	Fairview PA
Parker White Metal Company	550	42.6	Foundries	Fairview PA
Erie Coke Corporation	130	42.1	Iron and Steel Mills and Ferroalloy Manufacturing	Erie PA
FMC Technologies Measurement Solutions, Inc.	200	41.3	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	Erie PA
Erie Accuride LP	250	40.1	Foundries	Erie PA
Penn-Union Corp.	200	30.6	Other Electrical Equipment and Component Manufacturing	Edinboro PA

Source: Brookings Analysis of Moody's Industry Data

Of the firms with less than 100 employees, only Lake Erie Biofuels, also known as Hero BX, has an average annual output per employee greater than \$200,000. Pennsylvania's largest and most consistent biofuel producer with just 40 employees brings in annual sales of more than \$15 million, grossing \$375,000 per employee. In 2013, Pennsylvania produced 50 million gallons of biodiesel fuel. Lake Erie Biofuels was responsible for 99 percent of the output. When the firm began in 2005, more than 90 percent of its supply went to European buyers. But high tariffs on American biodiesel forced the firm to reexamine its domestic strategy. Now Lake Erie Biofuels must balance state and federal regulation, coupled with strident opposition from fossil fuel producers, to maintain its share of the alternative energy market. Part of remaining competitive is managing its size and its production as the company looks toward the future of its industry. "It's all about economies of scale, and you really need that to be successful in this business," Chris Peterson, vice president of Lake Erie Biofuel Erie facility, told the Pittsburgh Post-Gazette in 2014. "Size does matter."

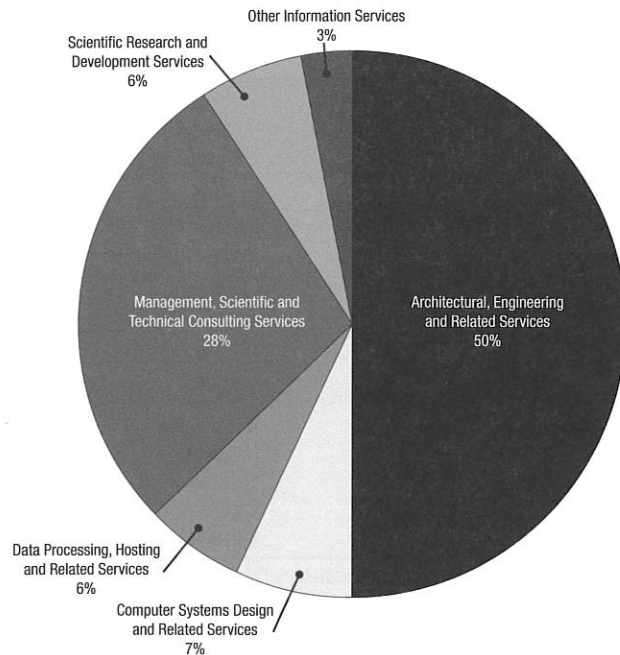
Top 10 Industries (n=23) with <100 Employees by Annual Sales (2013)

Company Name	Employees	Annual Sales (\$ Millions)	NAICS Title	Location
Lake Erie Biofuels, LLC	40	15.2	Basic Chemical Manufacturing	Erie PA
Swanson-Erie Corporation	60	9.4	Other General Purpose Machinery Manufacturing	Erie PA
Swanson Systems, Inc.	60	8.8	Other General Purpose Machinery Manufacturing	Erie PA
Erie Power Technologies Inc.	80	8.7	Architectural, Engineering, and Related Services	Erie PA
Weber Murphy Fox, Inc	50	8.2	Architectural, Engineering, and Related Services	Erie PA
Finish Thompson, Inc.	50	8.2	Other General Purpose Machinery Manufacturing	Erie PA
Van Air, Inc.	50	8	Other General Purpose Machinery Manufacturing	Lake City PA
Earl E. Knox Company	50	7.8	Other General Purpose Machinery Manufacturing	Erie PA
Provider Resources, Inc	70	7.3	Management, Scientific, and Technical Consulting Services	Erie PA
Great Lakes Automation Services, Inc.	50	7.1	Navigational, Measuring, Electromedical, and Control Instruments Manufacturing	McKean PA

Source: Brookings Analysis of Moody's Industry Data

The smaller firms are also significant because this is where competitive advanced services emerge in the matrix of Erie's advanced industries. Agility Marketing Group, with 380 employees and \$13.8 million in annual sales, is the only of Erie's advanced services among mid-sized firms. Architectural and engineering firms including Weber Murphy Fox and Erie Power Technologies, respectively, led the advanced services in output and have annual sales per employee between \$100,000 and \$150,000. Provider Resources, Inc. (PRI) rounds out the top ten firms with less than 100 employees providing 70 jobs and bringing in annual sales greater than \$7 million. PRI develops compliance, training, and education programs for health care industries.

Advanced Services (n=32), Erie MSA, 2013



Advanced services comprise roughly one-third of Erie's advanced industry profile. While architectural and engineering firms dominate 50 percent of services, five of the top ten firms with the greatest annual sales - a combined \$34.4 million - are those in the management, scientific, and technical consulting industry. The remainder of the top ten service industries includes firms from the architectural, engineering and related services (n=3), and those involved in data processing, hosting, and related services (n=2), which combine for \$31.5 million in annual sales. As a whole, advanced services account for more than \$103 million in annual sales and 16 percent of the sector's employment, making these contributors to economic impact and job creation an important part of Erie's economic portfolio. Nationally, advanced services have led the post-recession recovery and are responsible for 65 percent of new jobs in the advanced industries sector.

FUTURE OF ERIE'S ADVANCED INDUSTRIES

This essay examined the importance of workforce and alluded to the role that technological innovation plays in industrial recovery and global competition. However, Erie also needs an educational model that recognizes the importance of both academic achievement and the benefit of skill development. Indeed, many of the lessons young people need to learn do not come from the classroom. So-called "soft skills" are often cited as something learned on the job. In Erie

County, the City of Erie School District's Central Tech High School has embraced the value of vocational education in student development. Through hands-on projects designed to foster creative problem-solving, students are immersed in diverse environments that mimic a range of manufacturing plants.

To nurture its advanced industries, Erie needs to strengthen the support of its three vocation schools: Central Tech, Erie County Technical, and the Corry Area Career and Technology Education Center. These schools have been proactive in communicating with industry and working to close the gap between human capital and market demand. A recent survey of local business by the Erie Regional Chamber and Growth Partnership, known as "Project Jobs," suggests that demand is steady, particularly in advanced manufacturing. Survey respondents say there will be nearly 250 retirements in local advanced industries in 2015-2016. Employers expect to fill those vacancies rather than downsize local workforce based on responses to questions about job openings during the same time period. Appropriate vocational training and applied higher education curriculum will be paramount in retaining these advanced industry jobs because of the unrelenting digitization of the American workforce, in general, and the advanced workforce, in particular. Where it has not already taken shape, employers will soon place a premium on employees with skill sets that include coding and IT development, among others, because those skill sets will be critical to maintenance and operation

of equipment and services central to the success of America's advanced industries.

Traditionally, most American colleges and universities offered curriculum based in the liberal arts. While there remain many proponents of the liberal arts – the authors included – students are no longer gravitating toward programs with a focus on literature and the arts. According to a 2013 study by the U.S. Department of Education, more than 20 percent of the undergraduate population have enrolled as business majors, an increase of greater than 7 percent since the early 1970s. This suggests that students have shifted their intellectual priorities toward vocational preparation. Indeed, in 2014 President Barack Obama told an audience at a General Electric plant in Wisconsin that "folks can make a lot more, potentially, with skilled manufacturing or the trades than they might with an art history degree." Obama later apologized for the remark, saying it was a comment on the jobs market and not a criticism of art history. Nevertheless, this culturally significant sentiment is a radical departure from public opinion that a liberal arts education holds an esteemed and unimpeachable place in American education.

Stanford University professor Henry Etzkowitz concluded that the university's role is to shape the ecosystem of organizations that make innovation possible. These organizations are a combination of industry groups, government, and university faculty/staff that are interested in commercializing knowledge. They've been chartered to support the

creation, formation, and operation of new ideas that can, through “open innovation” – the crowd sourcing of thoughts and ideas for research and development – create new business and innovate existing industry through applied research and development.

The Erie Region has an opportunity to reshape its university system and gain a foothold in this competitive space through the Ignite Erie initiative. Erie County’s four institutions of higher education – Edinboro University of Pennsylvania, Gannon University, Mercyhurst University, and Penn State Erie, The Behrend College – published a report in the winter of 2013 detailing a potential collaboration titled *The Path Forward*. In this conceptual framework, the institutions laid out areas of commonality, strength, and collaborative direction, of which one was to support both entrepreneurship and innovation. In 2015, that goal became a reality when Deans from business, engineering, hospitality, and the sciences came together to solidify the Ignite Erie compact.

Through this aggressive venture, the four institutions have committed university resources and talent to strengthen the fledgling pieces of an innovation ecosystem. With financial support from the Erie County Gaming Revenue Authority, the Commonwealth’s Department of Community and Economic Development, and private fundraising efforts, they have committed to supporting startups and developing industry-sponsored research projects. It is a four-point approach that begins with increased communication among these

institutions, the economic development community, entrepreneurs, and industry leaders. It creates student and faculty teams to address the challenges of business development and product innovation; it creates physical space for collaboration through R&D facilities; and, it produces competitive products like market research, analysis, and implementation assistance. All of these are designed to fulfill the mission of revitalizing the community and strengthening the regional economy.

The effects of globalism and the aftermath of deindustrialization are clear. Changes in Erie’s 12th Street industrial corridor and the smoke stacks that remain are symbols of the past. However, if Etzkowitz’s assumptions about the importance of universities are correct, collaborations like Ignite Erie will change the landscape of regional competitiveness. Collaborations in advanced industry clusters and trends that value place and the economy are beginning to supplant the fickle loyalty of market-driven partners. Universities have a role to play in such affective change. They are anchor institutions literally staked in community investment.

CONCLUSIONS AND RECOMMENDATIONS

Harnessing relationships alone, however, will not be enough to ensure that Erie’s future is economically viable and sustainable. The era of technology-driven entrepreneurship has led community planners and angel investors to place unbridled hope that their

community will become the next Silicon Valley. As Ariella Cohen, editor-in-chief of the nonprofit online publication *Next City*, recently noted in an interview with American Public Media's *Marketplace*, "I think people are beginning to recognize that they're not Silicon Anything." Such recognition is critical to developing a realistic self-awareness about where development efforts should be set in the future. Cohen argues that the Rust Belt will not be saved or revitalized by transforming the region into something it doesn't know or systems it doesn't understand, or by ignoring the infrastructure and institutions that once proved to be the foundation of industry. "What's really important," she added, "is that the business community is talking with the universities." To be sure, entrepreneurs and investors looking toward technology for economic direction in global markets have a role to play in the revitalization of the region. But if it is to succeed, the Erie region must look toward the innovative practices that once made it a critical player in U.S. manufacturing. The infrastructure remains. How that infrastructure is utilized remains in question.

Advanced industries provide a framework that allows the region to move forward and to leverage hard assets in favor of economic progress, as well as provide a lens with which policymakers, analysts, and educators can measure the capitalization of local resources. These are not a means to an end, but advanced industries are a significant piece of the collaborative economic puzzle. Erie's advanced

industries are modest. Because of the sector's emphasis on R&D spending, however, the industries that compete within this sector are among the most significant drivers of long-term economic benefits.

The success of Erie's advanced industries will be the result of public, private, and civic partnerships that engender a skills culture, one which supports existing industry and makes possible the potential for growth. To this end, the authors offer the following recommendations:

- Regional leaders must gain a better understanding of R&D intensity throughout Erie's advanced industries. In doing so, the development picture, including technological innovation, economic growth, and the benefits of R&D spillover, will allow regional partners to curate and cultivate opportunities that strengthen industrial assets.
- Local entrepreneurs need access to "patient capital" – funding agencies that allow local industry, both young and small, an appropriate amount of time to move from innovation to full-scale production. Policymakers and stakeholders must help regional industry identify and secure "patient capital" in order to foster and maintain advanced industries.
- The nascent emphasis on skills education must continue to receive support from private industry as well as public and private educational institutions. Skills education must include traditional worksite experience, including apprenticeships, work-study, and internship

opportunities. Like “patient capital,” educational initiatives are only as strong as the opportunity they are given to succeed.

- Finally, the Erie region must identify innovation clusters that exist locally, regionally, and throughout the Great Lakes, both domestically and internationally. Innovation clusters can then be leveraged into metropolitan business plans that accelerate the innovation and output unique to Erie’s advanced industries.

The future of the Erie region is tied to the success of its advanced manufacturing and advanced services firms. However, we must remain cautiously optimistic about the future of advanced industries because of the region’s dependence on a few major firms. If the preceding analysis and recommendations are to have a lasting impact, it will be that the strength of the region’s premiere firms, when coupled with long-term public-private partnerships, will engender the growth of Erie’s small and mid-sized firms within the advanced industries super-sector, as well as across non-advanced industries. Through a commitment to innovation and skill building – which supports manufacturing and information-driven firms that create products, intellectual property, and services – Erie can once again establish strong foothold in manufacturing and a significant national identity for the products and services that emanate from northwest Pennsylvania.