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PROJECT



AMERICA'S ADVANCED INDUSTRIES

WHAT THEY ARE, WHERE THEY ARE,
AND WHY THEY MATTER

EXECUTIVE SUMMARY



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The need for economic renewal in the United States remains urgent. Years of disappointing job growth and stagnant incomes for the majority of workers have left the nation shaken and frustrated. At the same time, astonishing new technologies—ranging from advanced robotics and “3-D printing” to the “digitization of everything”—are provoking genuine excitement even as they make it hard to see where things are going.

ABOUT THE ANALYSIS

Individual advanced industries were identified using two criteria:

- An industry’s R&D spending per worker must fall in the 80th percentile of industries or higher, exceeding \$450 per worker
- The share of workers in an industry whose occupations require a high degree of STEM knowledge must also be above the national average, or 21 percent of all workers

An industry must meet both criteria to be considered advanced. Together the two thresholds identify 50 industries that invest heavily in technology innovation and employ skilled technical workers to develop, diffuse, and apply new productivity-enhancing technologies.

Hence this paper: At a critical moment, this report asserts the special importance to America’s future of what the paper calls America’s “advanced industries” sector.

Characterized by its deep involvement with technology research and development (R&D) and STEM (science, technology, engineering, and math) workers, the sector encompasses 50 industries ranging from manufacturing industries such as automaking and aerospace to energy industries such as oil and gas extraction to high-tech services such as computer software and computer system design, including for health applications.

These industries encompass the nation’s “tech” sector at its broadest and most consequential. Their dynamism is going to be a central component of any future revitalized U.S. economy. As such, these industries encompass the country’s best shot at supporting innovative, inclusive, and sustainable growth. For that reason, this report provides a wide-angle overview of the advanced industry sector that reviews its role in American prosperity, assesses key trends, and maps its metropolitan and global competitive standing before outlining high-level strategies to enhance that.

The overview finds that:

Advanced industries represent a sizable economic anchor for the U.S. economy and have led the post-recession employment recovery

Modest in size, the sector packs a massive economic punch:

- AS AN EMPLOYER AND SOURCE OF ECONOMIC ACTIVITY THE ADVANCED INDUSTRY SECTOR PLAYS A MAJOR ROLE IN THE U.S. ECONOMY.** As of 2013, the nation's 50 advanced industries (see nearby box for selection criteria) employed 12.3 million U.S. workers. That amounts to about 9 percent of total U.S. employment. And yet, even with this modest employment base, U.S. advanced industries produce \$2.7 trillion in value added annually—17 percent of all U.S. gross domestic product (GDP). That is more than any other sector, including healthcare, finance, or real estate.

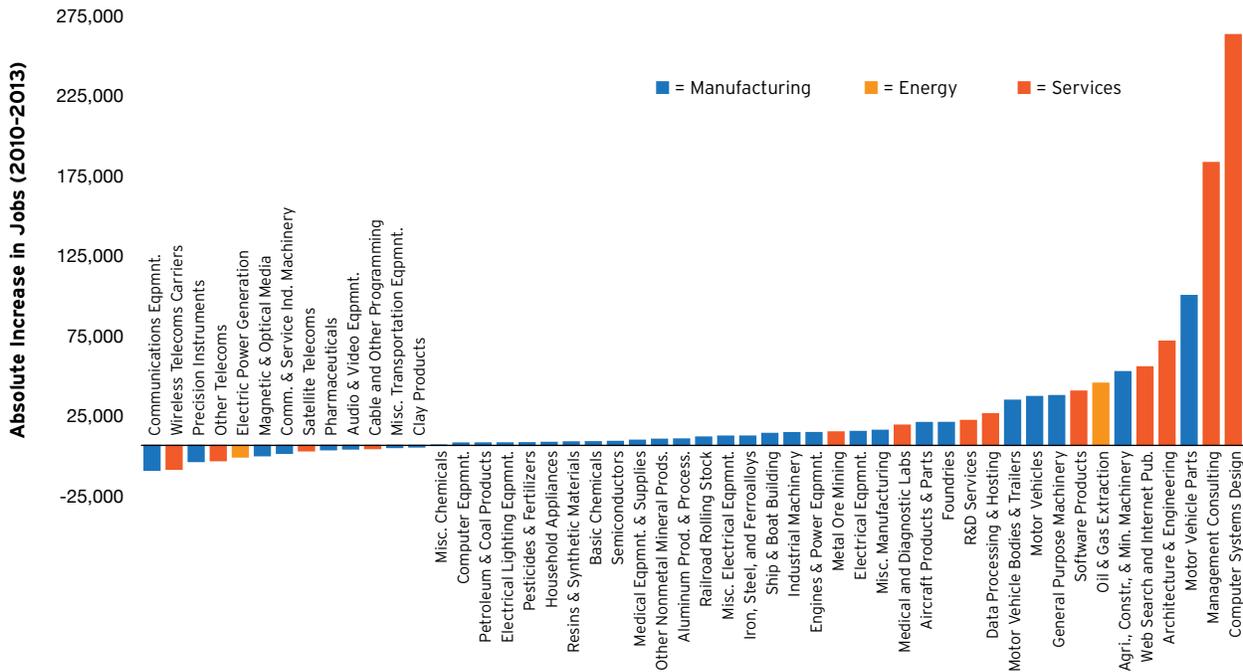
At the same time, the sector employs 80 percent of the nation's engineers; performs 90 percent of private-sector R&D; generates approximately 85 percent of all U.S. patents; and accounts for 60 percent of U.S. exports. Advanced industries also support unusually extensive supply chains and other forms of ancillary economic activity. On a per worker basis, advanced industries purchase \$236,000 in goods and services from other businesses annually, compared with \$67,000 in purchasing by other industries. This spending sustains and creates more jobs. In fact, 2.2 jobs are created domestically for every new advanced industry job—0.8 locally and 1.4 outside of the region. This means that in addition to the 12.3 million workers employed by advanced industries, another 27.1 million U.S. workers owe their jobs to economic activity supported by advanced industries. Directly and indirectly, then, the sector supports almost 39 million jobs—nearly one-fourth of all U.S. employment

The 50 Industries That Constitute the Advanced Industries Sector		
MANUFACTURING		ENERGY
Aerospace Products and Parts	Motor Vehicles	Electric Power Generation, Trans., and Distribution
Agr., Construction, and Mining Machinery	Navigation, Measurement, and Control Instruments	Metal Ore Mining
Aluminum Production and Processing	Other Chemical Products	Oil and Gas Extraction
Audio and Video Equipment	Other Electrical Equipment and Components	SERVICES
Basic Chemicals	Other General Purpose Machinery	Architecture and Engineering
Clay Products	Other Miscellaneous Manufacturing	Cable and Other Subscription Programming
Commercial and Service Industry Machinery	Other Nonmetallic Mineral Products	Computer Systems Design
Communications Equipment	Other Transportation Equipment	Data Processing and Hosting
Computers and Peripheral Equipment	Pesticides, Fertilizers, and Other Agr. Chemicals	Medical and Diagnostic Laboratories
Electric Lighting Equipment	Petroleum and Coal Products	Mgmt., Scientific, and Technical Consulting
Electrical Equipment	Pharmaceuticals and Medicine	Other Information Services
Engines, Turbines, and Power Trans. Equipment	Railroad Rolling Stock	Other Telecommunications
Foundries	Resins and Synthetic Rubbers, Fibers, and Filaments	Satellite Telecommunications
Household Appliances	Semiconductors and Other Electronic Components	Scientific Research and Development
Industrial Machinery	Ship and Boat Building	Software Publishers
Iron, Steel, and Ferroalloys	Medical Equipment and Supplies	Wireless Telecommunications Carriers
Motor Vehicle Bodies and Trailers	Reproducing Magnetic and Optical Media	
Motor Vehicle Parts		

- **IN TERMS OF THE SECTOR'S GROWTH AND CHANGE, THE TOTAL NUMBER OF JOBS IN THE SECTOR HAS REMAINED MOSTLY FLAT SINCE 1980, BUT ITS OUTPUT HAS SOARED.**

From 1980 to 2013 advanced industry output expanded at a rate of 5.4 percent annually—30 percent faster than the economy as a whole. Since the Great Recession, moreover, both employment and output have risen dramatically. The sector has added nearly one million jobs since 2010, with employment and output growth rates 1.9 and 2.3 times higher, respectively, than in the rest of the economy. Advanced services led this post-recession surge and created 65 percent of the new jobs. Computer systems design alone generated 250,000 new jobs. Certain advanced manufacturing industries—especially those involved in transportation equipment—have also added thousands of jobs after decades of losses

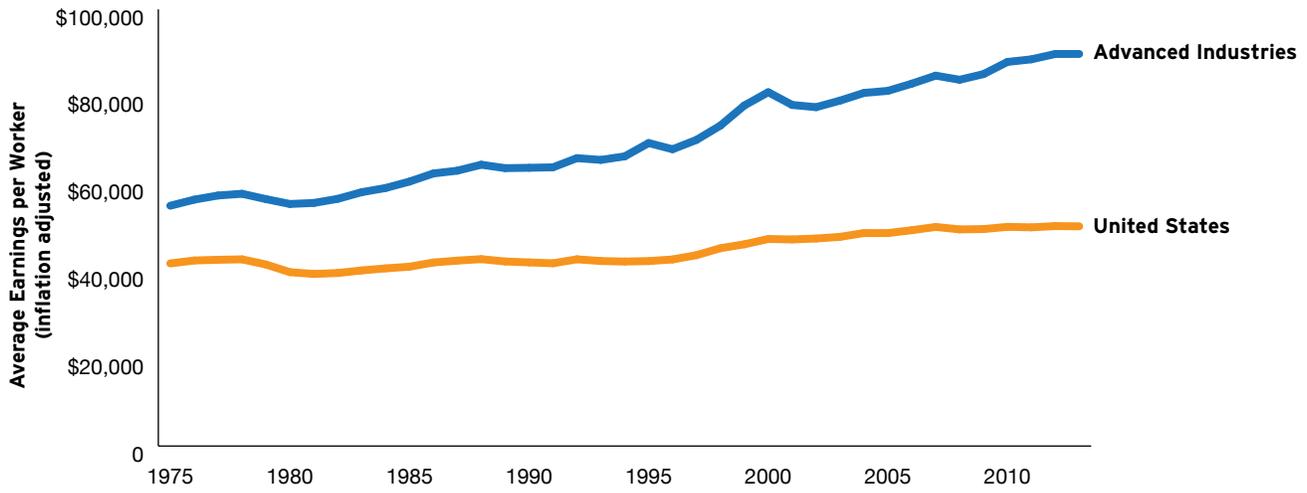
The advanced industry sector's post-recession employment surge has been broad-based but led by services



- **ADVANCED INDUSTRIES ALSO PROVIDE HIGH-QUALITY ECONOMIC OPPORTUNITIES FOR WORKERS.**

Workers in advanced industries are extraordinarily productive and generate some \$210,000 in annual value added per worker compared with \$101,000, on average, outside advanced industries. Because of this, advanced industries compensate their workers handsomely and, in contrast to the rest of the economy, wages are rising sharply. In 2013, the average advanced industries worker earned \$90,000 in total compensation, nearly twice as much as the average worker outside of the sector. Over time, absolute earnings in advanced industries grew by 63 percent from 1975 to 2013 after adjusting for inflation. This compares with 17 percent gains outside the sector. Even workers with lower levels of education can earn salaries in advanced industries that far exceed their peers in other industries. In this regard, the sector is in fact accessible: More than half of the sector's workers possess less than a bachelor's degree

Since 1975, average earnings in advanced industries have increased almost five times as fast as those in the overall economy

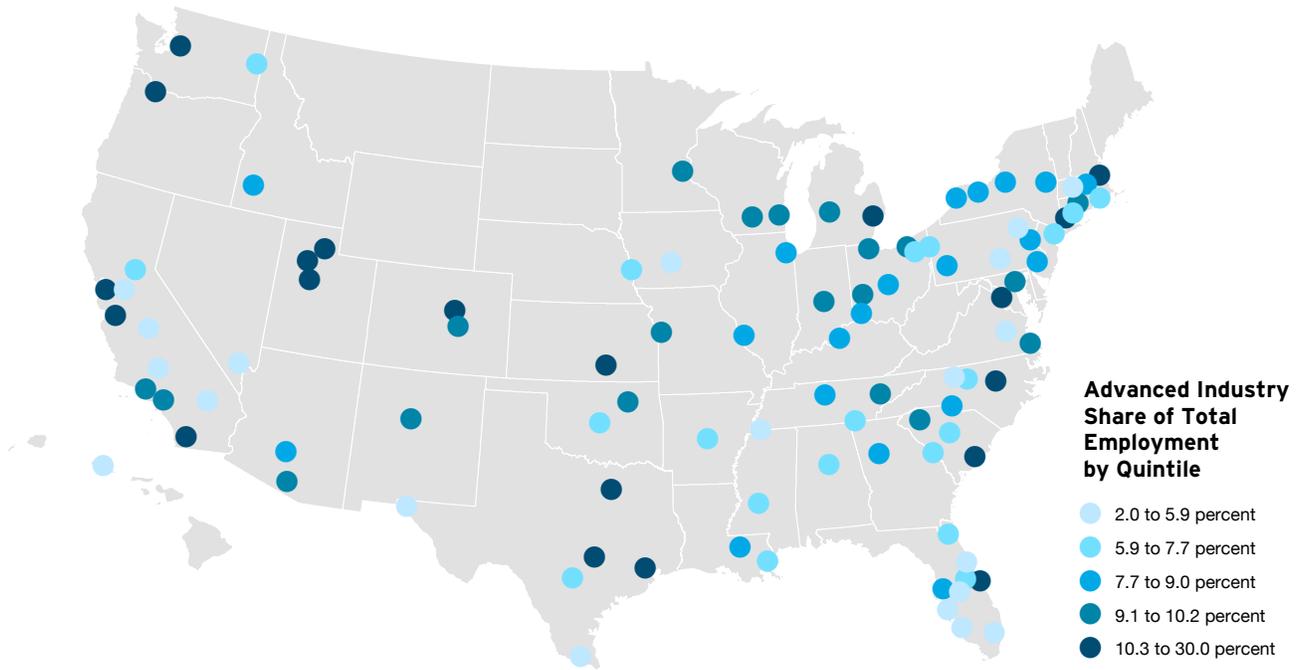


The advanced industries sector is highly metropolitan and varies considerably in its composition and depth across regions

Advanced industries are present in nearly every U.S. region, but the sector's geography is uneven:

- **ADVANCED INDUSTRIES TEND TO CLUSTER IN LARGE METROPOLITAN AREAS.** Looking across the country, the 100 largest metro areas contain 70 percent of all U.S. advanced industries jobs. In terms of the sector's local clustering, **San Jose** is the nation's leading advanced industry hub with 30.0 percent of its workforce employed in the sector. **Seattle** follows with 16.0 percent of its local jobs in advanced industries. **Wichita** (15.5 percent); **Detroit** (14.8 percent), and **San Francisco** (14.0 percent) follow. Overall, advanced industries account for more than one in 10 jobs in nearly one-quarter of the country's major metro areas
- **THIS CLUSTERING OCCURS IN A VARIETY OF CONFIGURATIONS.** Some metropolitan areas—such as **Grand Rapids, MI**; **Portland, OR**; and **Wichita**—focus heavily on advanced manufacturing pursuits such as automotive, semiconductor, or aerospace manufacturing, respectively, while metros like **Bakersfield** and **Oklahoma City** exhibit strong energy specializations. By contrast, services such as computer systems design, software, and research and development predominate in metropolitan areas like **Boston**, **San Francisco**, and **Washington**. For their part, **San Jose**, **Detroit**, and **Seattle** exhibit depth and balance across multiple advanced industry categories

Advanced industries' share of total employment varies significantly across major metropolitan areas



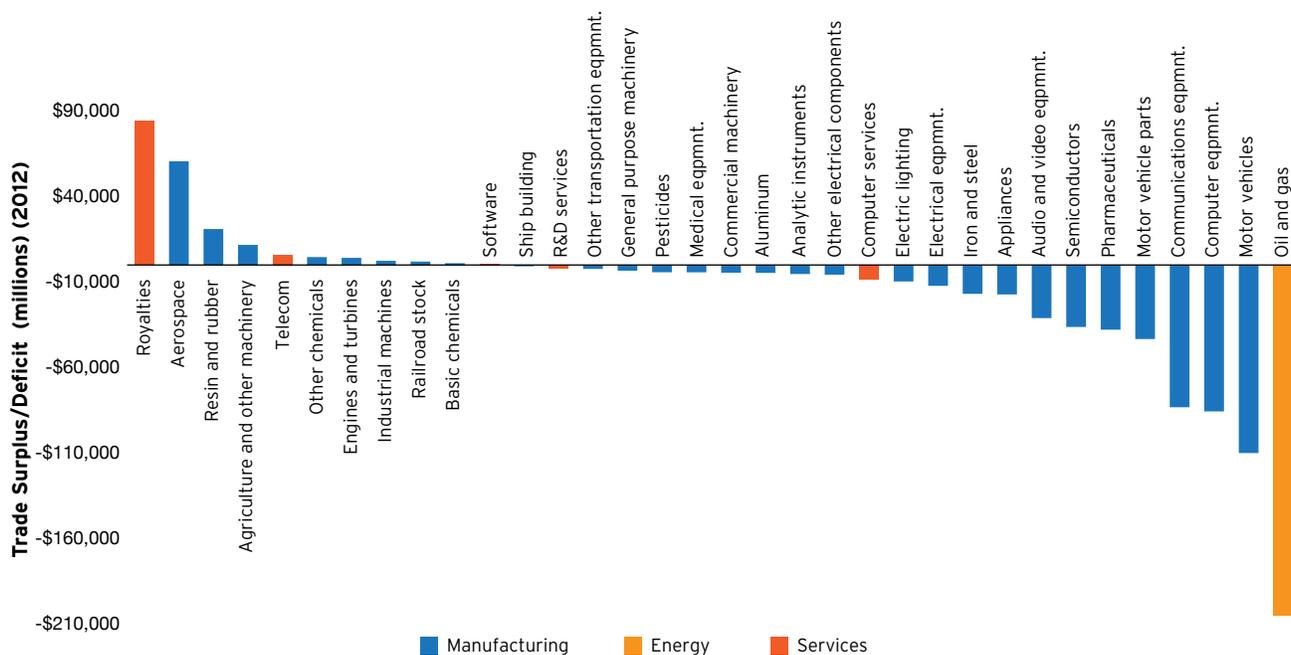
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- **OVERALL, THE NUMBER OF EXTREMELY DENSE CONCENTRATIONS OF ADVANCED INDUSTRY ACTIVITY HAS DECLINED.** In 1980, 59 of the country's 100 largest metropolitan areas had at least 10 percent of their workforce in advanced industries. By 2013, only 23 major metro areas contained such sizable concentrations

The United States is losing ground to other countries on advanced industry competitiveness

The United States has the most productive advanced industries in the world, behind only energy-intensive Norway. However, this competitiveness appears to be eroding:

- **THE NATION'S DECLINING CONCENTRATION IN ADVANCED INDUSTRIES AND ITS NEGATIVE TRADE BALANCE IN THE SECTOR DO NOT BODE WELL.** Since 2000, the sector's employment and output as a share of the total U.S. economy has shrunk, and the nation's standing on these measures now lags world leaders. Equally worrisome is the balance of trade in the sector. Although advanced industries export \$1.1 trillion worth of goods and services each year and account for roughly 60 percent of total U.S. exports, the United States ran a \$632 billion trade deficit in the sector in 2012, in line with similar yearly balances since 1999. To be sure, a handful of individual advanced industries such as royalties and other intellectual property and aerospace manufacturing enjoy trade surpluses that exceeded \$60 and \$80 billion in 2012. However, numerous areas of historical strength such as communications equipment, computer equipment, motor vehicles, and pharmaceuticals now run sizeable deficits, as do high-value R&D services and computer and information services

With few exceptions, the United States runs a significant trade deficit in advanced industries



- NOTWITHSTANDING THE NATION'S STRONG INNOVATION ENTERPRISE, THE UNITED STATES' ADVANTAGE ON THIS FRONT IS SLIPPING.** For certain the advanced industry sector remains the key site of U.S. technology gains. However, the United States is losing ground relative to other countries on measures of innovation performance and capacity. For example, the U.S. share of global R&D and patenting is falling much faster than its share of global GDP and population, meaning that U.S. slippage cannot simply be attributed to demography or macroeconomic convergence. Likewise, America's research dominance looks less impressive after adjusting for the size of its working age population. Turning to the nation's critical regional innovation ecosystems, surprisingly few U.S. metropolitan areas rank among the world's most innovative—as measured by patent cooperation treaty applications per capita. Among the nation's most patent-intensive regions, just two—**San Diego** and the **San Jose-San Francisco** combined area—rank in the global top 20 and just two more (**Boston** and **Rochester**) score in the top 50
- JOBS IN ADVANCED INDUSTRIES ARE AVAILABLE AT ALL LEVELS OF EDUCATION, BUT ONLY A NARROW EDUCATIONAL AND TRAINING PIPELINE CHANNELS POTENTIAL WORKERS INTO THE SECTOR.** At the same time, the sector faces a labor supply challenge. By definition, an outsized share of advanced industries' workers can be found in STEM occupations. So the sector is a critical storehouse of the nation's STEM knowledge base. However, globalization and technological change are increasing the education requirements of the sector, sharpening its skills challenge. Amid these trends, many advanced industry employers report difficulties finding qualified workers, which places a drag on their competitiveness. For example, a posting for a STEM-related occupation in an advanced industry remains online for an average of 43 days. This compares with 32 days for non-STEM ads. Contributing to those hiring delays is the fact that the U.S. education system graduates too few college students in STEM fields and does too little to adequately prepare children in mathematical and scientific concepts. U.S. youths and adults alike perform much more poorly on international exams of math and science competencies than

many of their peers in developed countries. Moreover, even students in the top 10 percent of U.S. performers score well below their highest-scoring peers in other developed countries

Complicating the sector's human capital challenges are sharp regional variations in the availability of skills. For example, in 15 of the largest 100 U.S. metropolitan areas the number of STEM graduates as a share of the young adult population (aged 20 to 34) exceeds Finland's, which holds the highest share internationally. These skills poles include some of the nation's most successful advanced industry hubs, including **Boston, San Jose, Raleigh, and Provo**. At the other end of the spectrum, however, 33 large U.S. metropolitan areas' STEM graduation rates trail those of Spain, which ranks 24th internationally. These metropolitan areas include prominent such places like **Phoenix, Las Vegas, Miami, Dallas, Detroit, Houston, and Kansas City**. This variation in the availability of human capital places a serious drag on the ability of many metropolitan areas to support advanced industries locally and nationally

The nation's private and public sectors must engage to defend and expand America's advanced industries

Looking forward, this description and assessment of the advanced industry sector points to significant opportunity—but also challenges.

On the positive side, the combination of intensive technology investment and highly skilled STEM workers in the advanced industry sector represents a potent source of U.S. prosperity—including for workers without a bachelor's degree. Advanced industries power the national economy and their success is a prerequisite for building an opportunity economy in the United States. Moreover, the report makes clear that a distinct advanced industry geography has emerged within which varied combinations of industries cluster in various regions to avail themselves of key innovation resources, skilled workers, and supplier networks. In this respect, America's advanced industries are not national. They are local, and in regions like Austin, Boston, San Diego, Seattle, and Silicon Valley they are world-class hubs of prosperity.

Yet too many U.S. advanced industries and local advanced industries clusters are ceding global leadership.

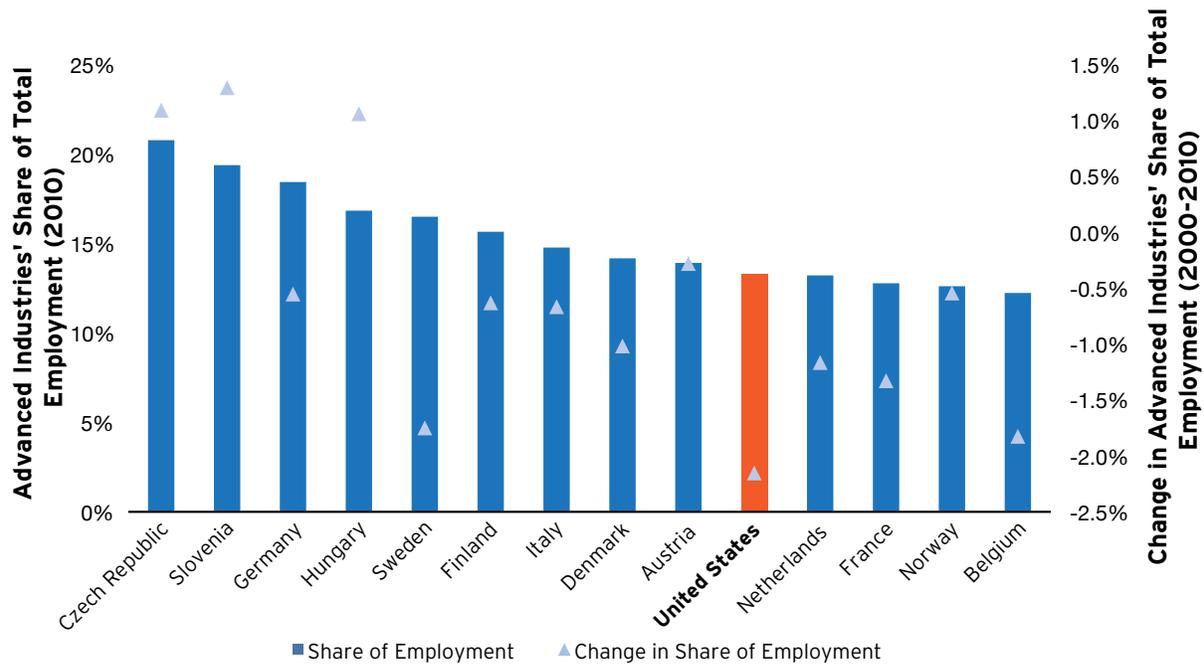
The deterioration of the nation's balance of trade in advanced technology products over the last decade raises especially sobering questions, not just about trade policy, but about the long-term vitality of the sector. Likewise, too few regional advanced industry ecosystems now retain the technology inputs, labor pools, and supplier density to generate the synergies that drive global competitiveness. Making matters worse is the gridlock in Washington that continues to preclude national action to strengthen advanced industries through sensible corporate tax reform or strategic trade liberalization and enforcement.

All of which means private and public sector leaders—particularly those working at the state and regional level—must engage. Already numerous state and regional partnerships are working to expand America's advanced industries, often by attending to the fundamental inputs needed to ensure these industries' long-term growth.

Yet more can and should be done. Among other initiatives, the nation's private- and public-sectors should together:

- **COMMIT TO INNOVATION.** Innovation remains the only lasting source of advantage for firms and places in the advanced industry sector, yet its speed and complexity are ratcheting up and demanding new strategies. Accordingly, both the private and public sectors need to radically rethink their technology development strategies. Lead actors in firms and government each need to ramp up the scale of their innovation efforts and reconsider the formats through which they conduct them. More R&D conducted within new, more open or networked innovation models will be

U.S. employment in advanced industries is low by international standards and falling rapidly



necessary in the coming years

- RECHARGE THE SKILLS PIPELINE.** More qualified workers with different and more technical skillsets are also critical to the future competitiveness of the sector. However, the skills prerequisites of modern advanced industries have been changing faster than the country's ability to train the needed workers. Now that the economy is heating up and firms are beginning to expand again, both private- and public-sector actors—often in partnership—need to bear down on improving the availability of skilled workers by developing smart, industry led, sector-specific, regional skills initiatives. Overall, firms need to get much more involved in developing the skills pipeline and the public sector must become much more responsive to their needs
- EMBRACE THE ECOSYSTEM.** Finally, firms, governments, and other relevant actors must work to strengthen the nation's local advanced industry ecosystems—the regional industrial communities within which firms operate. Innovation and skills development do not happen just anywhere. They happen in places, most notably within metropolitan regions, where firms tend to cluster in close geographic proximity, whether to profit from local knowledge flows, access skilled workers, or tap regional supplier networks. Unfortunately, though, in too many places America's advanced industry clusters are thin or eroded after decades of offshoring and disinvestment. It is critical, therefore, that private- and public-sector leaders work together to renew the vitality of the nation's regional advanced industries ecosystems—the most durable foundations of U.S. competitiveness in the sector. Firms should seek to quantify the value they derive from vibrant local ecosystems even as localities and states work to enhance the local environment for advanced industry activity through investments in anchor institutions and support for cluster infrastructure

America's advanced industries are a critical anchor of national prosperity. Business leaders, government, and the civic sector need to work together in new ways to augment their vitality. ■

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Advanced Industries Series

This paper is part of the Brookings Metropolitan Policy Program's Advanced Industries Series, which is aimed at describing and advancing the country's R&D- and knowledge-intensive advanced industries. The series provides groundbreaking research focused on assessing the large role these industries play in delivering regional and national prosperity and providing recommendations to enhance U.S. competitiveness in the sector. The sector's competitiveness and growth are prerequisites for any future broadly shared prosperity.

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- *Powering Advanced Industries, State by State*
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