Building U.S. Manufacturing Competitiveness

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Subcommittee on Innovation, Data and Commerce

Marc Jarsulic
Senior Fellow and Chief Economist
Center for American Progress

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Thank you, Chairman Bilrakis and Ranking Member Schakowsky, for the opportunity to testify on this important topic. I am a Senior Fellow and Chief Economist at the Center for American Progress. Today, I will attempt to outline the importance of a strong manufacturing sector for both economic competitiveness and national security, and the need for effective industrial policy in reaching both those goals.

The importance of manufacturing for competitiveness and security

Manufacturing has historically been a source of productivity growth and high wage employment. Much of manufacturing productivity growth has derived from innovation – adoption of new technologies rather than merely adding more capital equipment per unit of labor. The ability of many U.S. manufacturers to operate at the technological frontier has made U.S. manufactured goods competitive internationally, and until recently the U.S. was the world's largest manufacturing exporter.

While in the aggregate much of U.S. manufacturing productivity remains at frontier levels, the competitive lead has been eroded. For example, between 1995-2004 U.S. manufacturing productivity growth was higher than that of Germany, a major advanced economy manufacturing competitor. But during recent decades labor productivity growth rates in the

German economy have converged with ours.[1] In addition, German manufacturing total factor productivity (TFP) growth – the fraction of output growth which is not attributable to increased inputs to production, and which is commonly used as a measure of innovation [2] -- exceeded that of the U.S. and was more or less evenly distributed across all manufacturing sectors. [3]

U.S. manufacturing has also been challenged by the rise of China as a competitor. China has overtaken the U.S. as the world's leader in manufacturing value added, and leads the U.S. in manufacturing exports.[4] Millions of domestic manufacturing jobs were lost to the "China shock" beginning in 2000, as domestic Chinese firms entered the U.S. market as competitors, and as an increasing share of U.S. manufacturing employment was off-shored to China and elsewhere by U.S. multinationals.[5]

In addition, in 2015 the Chinese government announced a program called "China 2025", which has the goal of rapidly developing capacity in ten high-tech industries. They include artificial intelligence, advanced robotics, energy saving vehicles, and biopharma. The stated goal of the plan is to significantly improve manufacturing quality, productivity and innovation, and by

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[1] Martin Neil Baily, Barry Bosworth, and Siddhi Doshi, "Productivity comparisons: Lessons from Japan, the United States and Germany", Brookings Institution, January 2020, p. 11, available at https://www.brookings.edu/wp-content/uploads/2020/01/ES-1.30.20-BailyBosworthDoshi.pdf.

[2] See Robert Shackleton, Total Factor Productivity Growth in Historical Perspective, Congressional Budget Office working paper, available at https://www.semanticscholar.org/paper/Total-Factor-Productivity-Growth-in-Historical-Shackleton/b436d848641fd396e13094d3327255cb777348cd.

[3] Baily et al., op. cit, pp. 35-36.

[4] Marc Levinson, "U.S. Manufacturing in International Perspective," Congressional Research Service, February 21, 2018, p.2, available at https://fas.org/sgp/crs/misc/R42135.pdf; World Trade Organization, World Trade Statistical Review 2022, Table A17, available at https://www.wto.org/english/res_e/booksp_e/wtsr_2022_c5_e.pdf.

[5] David Autor, David Dorn, and Gordon H. Hanson, "The China Shock: Learning from Labor-Market Adjustment to Large Changes in Trade," *Annual Review of Economics* 8 (2016): 223, available at http://www.ddorn.net/papers/Autor-Dorn-Hanson-ChinaShock.pdf; Daron Acemoglu and others, "Import Competition and the Great US Employment Sag of the 2000s," *Journal of Labor Economics* 34 (S1, Part 2) (2016): S141–S198, available at https://economics.mit.edu/files/11560; Christoph E. Boehm, Aaron Flaaen, and Nitya Pandalai-Nayar, "Multinationals, Offshoring and the Decline of U.S. Manufacturing", (Cambridge, MA: National Bureau of Economic Research, 2019), available at https://www.nber.org/papers/w25824.

2049 have the leading global position in advanced manufacturing.[6] The tools used to achieve these goals include subsidies, investments in foreign companies to obtain technology, and technology acquisition via joint venture requirements for foreign firms operating in China. The success of this effort is yet to be determined, but the government commitment and scale of resources available for the effort appear formidable.

These challenges to U.S. leadership in advanced manufacturing create both economic and security risks. Under the existing global division of labor in semiconductor production, both kinds of risk are substantial. The U.S. is dominant in semiconductor design, but has a relatively small and declining share of chip fabrication. Taiwan holds the dominant position in fabrication, operating leading-edge chip "foundries" that produce to customer specifications. Assembly, testing and packaging of semiconductors into finished components is done predominantly by contract manufacturers in Taiwan and China. This means that important elements of the semiconductor supply chain are subject to events in other countries, and, in the case of firms located in Taiwan and China, to Chinese government interference.

The reduction in domestic auto production, caused by chip shortages, over the past two years illustrates the economic risks posed by disruptions to semiconductor supply chains. Security risks are illustrated by DoD's ongoing reliance on Asian producers of micro-printed circuit boards (micro-PrCB's), which are essential to many national defense electronic systems. The economics of commercial micro-PrCB production have located it mostly outside the U.S.,

[6] China 2025 is described in James McBride and Andrew Chatzky, "Is 'Made in China 2025' a Threat to Global Trade," Council on Foreign Relations, May 13, 2019, available at https://www.cfr.org/backgrounder/made-china-2025-threat-global-trade; and in Karen M. Sutter, " 'Made in China 2025' Industrial Policies: Issues for Congress, Congressional Research Service, August 11, 2020, available at https://fas.org/sgp/crs/row/IF10964.pdf.

and foreign producers are developing technical and cost advantages that force DoD to depend on them.[7]

The geography of semiconductor production has been heavily influenced by foreign government interventions. Taiwan, for example, provides subsidies for land, construction, and manufacturing equipment that lowers fabrication costs by 25-30 percent. China has provided a single firm, Yangtze Memory Technology, with $24B in subsidies, has allocated $100B in support for 60 new manufacturing facilities, and its Integrated Circuit Investment Fund has provided $21B in capital to firms producing semiconductor manufacturing equipment, with an additional $29B on the way.[8]

Requirements for frontier-level advanced manufacturing

Advanced manufacturing is based on scientific discovery, the translation of discoveries into prototype products and production processes, adequate standards and tests to control quality, and a well-trained workforce. Because private actors cannot capture all the benefits of investing in these prerequisites – it is hard, for example to keep scientific ideas secret, or prevent well-trained workers from leaving for other employment – the level of investment in each of them is insufficient. In addition, uncertain demand sometimes acts as a barrier to needed manufacturing innovation.

- **Basic science, proof of concept, and standards**

It is widely recognized that public support for basic scientific research contributes significantly to U.S. economic success, in advanced manufacturing and other sectors. However,

[7] Department of Defense, *FY2019 Industrial Capabilities Report to Congress*, pp. 105-106, available at https://www.businessdefense.gov/Portals/51/Documents/Resources/USA000954-20%20RPT%20Subj%20FY19%20ICR%2007092020.pdf?ver=2020-07-10-124452-180.
[8] https://www.whitehouse.gov/wp-content/uploads/2021/06/100-day-supply-chain-review-report.pdf.

the recognition of the public good benefits of basic science is often linked to a simplified picture, in which the discoveries of basic science are handed off to manufacturers, who do applied research and development to produce commercial products. This schematic misses two intervening steps which have public good characteristics:

> “One is "proof-of-concept research" to establish broad "technology platforms" that can then be used as a basis for developing actual products. The second is a technical infrastructure of "infratechnologies" that include the analytical tools and standards needed for measuring and classifying the components of the new technology; metrics and methods for determining the adequacy of the multiple performance attributes of the technology; and the interfaces among hardware and software components that must work together for a complex product to perform as specified. If the public–private dynamics are not properly aligned to encourage proof-of-concept research and needed infratechnologies, then promising advances in basic science can easily fall into a "valley of death" and fail to evolve into modern advanced manufacturing technologies that are ready for the marketplace. Each major technology has a degree of uniqueness that demands government support sufficiently sophisticated to allow efficient adaptation to the needs of its particular industry, whether semiconductors, pharmaceuticals, computers, communications equipment, medical equipment, or some other technology-based industry.” [9]

The relatively slow development of biopharmaceuticals, after significant NIH investment in life-science research, has been attributed to the absence of a well-developed proof of concept technology platform.[10]

- **Workforce development**

In addition to scientists and engineers, advanced manufacturing requires a well-trained, flexible industrial workforce. The National Research Council has recognized this. They have pointed out that the success of German manufacturing relies on the country’s “dual system” of vocational training, in which students engage in academic training for practical work, while

[9] Gregory Tassey, “Competing in Advanced Manufacturing: The Need for Improved Growth Models and Policies,” *Journal of Economic Perspectives*, Volume 28, Number 1, Winter 2014, pp. 27-48, available at https://www.aeaweb.org/articles?id=10.1257/jep.28.1.27; *see also*, William B. Bonvillian and Peter L. Singer, *Advanced Manufacturing*, (Cambridge: MIT Press, 2017).
[10] Tassey, op. cit., p. 38.

simultaneously receiving training in apprenticeship programs run by firms or public institutes.[11] This commitment to workforce training provides industry with highly skilled workers who can adapt to changing production processes. It also provides workers with recognized credentials, which give them mobility and bargaining power with their employers. These credentials, together with extensive union representation, and mandatory works councils and worker representation on corporate boards, help to deliver the high real wages paid to German manufacturing workers.[12]

- **Demand certainty**

Uncertain demand also can inhibit manufacturing innovation. It is, for example, recognized that the scale of demand is a key limitation on manufacturing innovation in the U.S. defense sector. Although great amounts of money are spent on defense overall, manufacturers outside the defense sector have limited incentive to innovate products that might have defense applications. Relative to commercial products, the defense market can be small.

To address the demand problem, the DoD at times works to find ways to introduce defense-important technology into commercial applications. For example, in the 1990's DARPA successfully funded research and development in optoelectronics. However, in order to stimulate continued private sector development of the technology, DARPA funded two private-public partnerships that had the goal of establishing commercial fiber-optic networks. These efforts contributed to subsequent broad commercial adoption of fiber optics.[13]

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[11] National Research Council. *21st Century Manufacturing: The Role of the Manufacturing Extension Partnership Program*. (Washington, DC: The National Academies Press, 2013), p. 230, available at https://doi.org/10.17226/18448.

[12] See David Madland, "The Future of Worker Voice and Power", Center for American Progress, October. 2016, available at https://cdn.americanprogress.org/wp-content/uploads/2016/10/06051753/WorkerVoice2.pdf?_ga=2.133094987.43744973.1612982836-685557270.1612982836.

[13] Potomac Institute, "Consortia Analysis and Recommendations Trade Study", December 2017, p. 15, available at https://potomacinstitute.org/images/studies/CARTSsm.pdf.

Demand certainty, on the other hand, has facilitated important manufacturing innovation. A salient example is presented by the development of the world solar photovoltaic panel (PV) industry. Until the late 1990's there was no mass market for PV's, there was limited production capacity for what was a niche product, and the cost of PV power was high. However, the decisions by the governments of Japan, Germany and Spain to subsidize the adoption of solar power created a surge in demand for solar panels.[14] Because the demand could not be met by existing PV companies, an opening was created for new entrants.

In the early 2000's several Chinese start-up companies entered the PV market, and now account for well over half of all PV's produced in the world.[15] Because of continuing technical improvements and scale economies in production, the cost of solar power has decreased dramatically, and some solar power is now competitive with other sources of electricity.[16]

The need for industrial policy

With the major exceptions of support for basic scientific research, and defense-related interventions by DARPA and other agencies, domestic policy has not systematically focused on manufacturing in recent decades. Given the challenges facing U.S. industry, and the pervasive public-goods obstacles to required investment, this neglect has been anything but benign. It is therefore remarkable and encouraging that several pieces of legislation passed in the 117th Congress represent important advances in industrial policy.

[14] Christian Binz and Laura Diaz Anadon, "Unrelated diversification in latecomer contexts: Emergence of the Chinese solar photovoltaics industry," *Environmental Innovation and Societal Transitions*, Vol. 28, 2018, p. 25, available at https://doi.org/10.1016/j.eist.2018.03.005.

[15] "The Solar-Powered Future is Being Assembled in China," Bloomberg News, September 14, 2020, available at https://www.bloomberg.com/features/2020-china-solar-giant-longi/.

[16] *See* Lazard, "Levelized Cost of Energy, Version 14.0", available at https://www.lazard.com/perspective/levelized-cost-of-energy-and-levelized-cost-of-storage-2020/.

The Infrastructure Investment and Jobs Act (IIJA) is a major step in restoring and upgrading basic public infrastructure, crucial to the daily lives of Americans, and to the efficient operation of manufacturing and other businesses. In addition to reauthorizing existing programs, the IIJA provides $284 billion over five years to improve the surface transportation network – roads and bridges, passenger and freight rail, airports, ports and waterways, public transit, and electric vehicle infrastructure, buses and transit. It includes an additional $266 billion over five years for core infrastructure -- power, water, broadband, environmental resilience, and environmental remediation.[17]

The CHIPS and Science Act provides substantial new support for basic scientific research in strategic areas, public-private partnerships with industry, and workforce training. It includes $200 billion to support STEM education, research and development, and workforce development through the NSF and Departments of Energy and Commerce. An additional $53 billion supports semiconductor manufacturing, R&D, and workforce development. There are $24 billion in tax credits for chip production, including support for National Institute of Standards and Technology.[18]

The Inflation Reduction Act (IRA) provides important incentives for private investment in clean energy and climate-related production over the next decade. Manufacturers will receive about $48 billion in tax incentives, which will include production of batteries and the critical minerals they require, and solar and wind energy components. Demand for electric vehicle production will be supported by about $43 billion in consumer tax incentives. In addition, IRA's

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[17] McKinsey & Company, "The U.S. Bipartisan Infrastructure Law: Breaking it Down", November 12, 2021, available at https://www.mckinsey.com/industries/public-and-social-sector/our-insights/the-us-bipartisan-infrastructure-law-breaking-it-down; *see also* Brookings Institution, "Breaking Down the Infrastructure and Jobs Act", available at https://www.brookings.edu/interactives/brookings-federal-infrastructure-hub/.

[18] McKinsey & Company, "The CHIPS and Science Act: Here's What's in It", October 4, 2022, available at https://www.mckinsey.com/industries/public-and-social-sector/our-insights/the-chips-and-science-act-heres-whats-in-it.

large investment in green power will provide long-term benefits to manufacturing, other businesses, and households generally.[19]

Taken together, these three bills provide both public goods and private sector incentives that will strengthen our manufacturing competitiveness and national security. They will upgrade basic infrastructure, support basic science and its commercialization in strategic areas, and provide significant new support for workforce development. They also support investment and demand for climate-related manufacturing, which is needed to address the issue of climate change.

Conclusion

Competitiveness in advanced manufacturing delivers important benefits. It is a source of productivity growth and higher-wage employment. It also limits national security risks that arise when we lack access to frontier technology or lack dependable sources for important manufactured products.

At the moment our manufacturing sector faces important challenges. While in the aggregate much of U.S. manufacturing productivity remains at frontier levels, the competitive lead has been eroded. Productivity in other advanced economy competitors is converging to ours. U.S. manufacturing has also been challenged by competition from China – it has overtaken the U.S. as the world's leader in manufacturing value added, and leads the U.S. in manufacturing exports. In addition, the Chinese government is devoting considerable resources to move ahead in crucial areas such as artificial intelligence, advanced robotics, energy saving vehicles, and biopharma.

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[19] McKinsey & Company, "The Inflation Reduction Act: Here's What's In It", October 24, 2022, available at https://www.mckinsey.com/industries/public-and-social-sector/our-insights/the-inflation-reduction-act-heres-whats-in-it.

To meet these challenges we need the help of effective industrial policy – one that supports basic science, applied research and development to invent prototypes and production processes, adequate standards and tests to control quality, and an extraordinarily well-trained workforce. We are fortunate that Congress has taken steps to meet these important policy needs.

Summary

- **The importance of manufacturing for competitiveness and security**

Competitiveness in advanced manufacturing delivers important benefits. It is a source of productivity growth and higher-wage employment. It also limits national security risks that arise when we lack access to frontier technology or lack dependable sources for important manufactured products.

- **Requirements for frontier-level advanced manufacturing**

At the moment our manufacturing sector faces important challenges. While in the aggregate much of U.S. manufacturing productivity remains at frontier levels, the competitive lead has been eroded. Productivity in other advanced economy competitors is converging to ours. U.S. manufacturing has also been challenged by competition from China – it has overtaken the U.S. as the world's leader in manufacturing value added, and leads the U.S. in manufacturing exports. In addition, the Chinese government is devoting considerable resources to move ahead in crucial areas such as artificial intelligence, advanced robotics, energy saving vehicles, and biopharma.

- **The need for industrial policy**

To meet these challenges we need the help of effective industrial policy – one that supports basic science, applied research and development to invent prototypes and production processes, adequate standards and tests to control quality, and an extraordinarily well-trained workforce. We are fortunate that Congress has taken steps – through IIJA, CHIPS, and IRS -- to meet these important policy needs.