POLICY RECOMMENDATIONS TO STIMULATE U.S. MANUFACTURING INNOVATION

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INTRODUCTION

After dropping significantly in the Great Recession, inflation-adjusted U.S. manufacturing output has continued to decline as a share of gross domestic product (GDP), down 3.5 percent between 2009 and 2019 (0.41 percentage points), even with the strong cyclical rebound in the motor vehicle sector. While U.S. manufacturing performs adequately in a few sectors—such as primary metals, chemicals, computers and electronic products (including semiconductors)—most other sectors are smaller as share of the U.S. economy than they were a decade ago.[1] To boost U.S. manufacturing output and innovation, effective manufacturing strategies—articulated at both the federal and state levels and underpinned by a suite of effective, specific policies—will be needed. This report first examines the underperformance of American manufacturing and then examines how a concerted suite of policies—focused on addressing strategy and analysis, technology development and diffusion, finance, tax, and talent challenges and opportunities—could be implemented to revitalize America's manufacturing economy.

THE STATE OF AMERICA'S MANUFACTURING ECONOMY

Across a number of facets—from manufacturing value added, productivity, and employment to trade balances—America's manufacturing economy continues to underperform its potential. Perhaps the most significant indicator is weakness in real U.S. manufacturing output, which has fallen as a share of GDP over the last decade. In fact, real manufacturing value added declined 13 percent from 2007 to 2019, from 13.2 percent of GDP to 11.5 percent. And, when controlling for the statistical overstatement of output growth in the computer industry, it fell by 20 percent, from 12.1 to just 9.7 percent.[2] In terms of manufacturing value added as a share of U.S. GDP, it has fallen from 16 percent in 1997 to just 11 percent in the third quarter of 2019.[3] And while some contend that manufacturing value added as a share of GDP is fated to weaken in advanced economies, the reality is that manufacturing's contribution to German GDP is twice the share as in America, while it remains higher in other economies, such as Austria (17 percent), Japan (21 percent), Korea (27 percent), and Switzerland (18 percent).[4] Meanwhile, the U.S. share of global manufacturing activity has fallen from 28 percent in 2002 to 18 percent in 2016.[5]

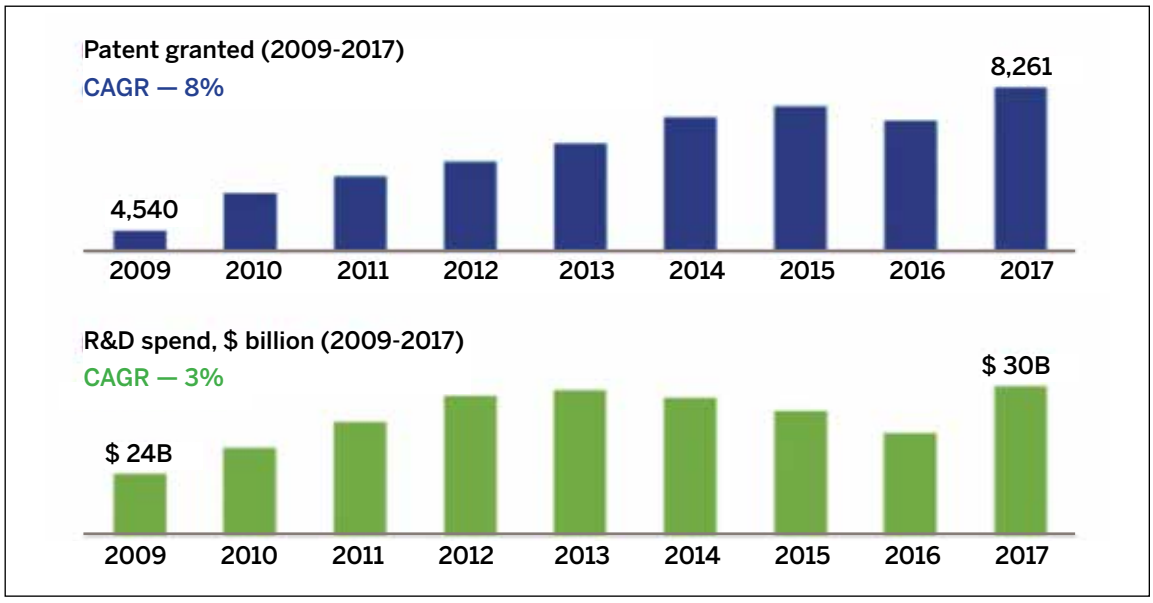
A key weakness in the U.S. manufacturing innovation system has been gaps in the ability to translate technologies invented in U.S. corporate, university, or national research laboratories into products manufactured at scale in the United States. One aspect of this is that, even while the United States leads the world in research and development (R&D) investment, it invests extremely little in R&D focused on technology translation and industrial production R&D compared to peer nations. For instance, the United States invests just 0.5 percent of its total R&D on industrial production R&D, compared to 7 percent in Japan, 12 percent in Germany, and 30 percent in South Korea, and in fact U.S. investment is a fraction of the OECD country average,

about 18 percent.[6] In other words, the OECD average for investment in industrial production R&D is almost 40 times greater than the U.S. level.

A July 2019 study by Deloitte examined R&D investment as a share of revenues from 2009 to 2017 by 217 U.S. headquartered S&P 500 companies, 57 of which were in the industrial and materials sector, finding that their R&D intensity, at 3 percent, significantly trailed investments made by companies in other sectors of the economy, such as those in health care (17 percent) and information technology (IT) and communication services (16 percent).[7] Moreover, R&D investment by U.S. industrial manufacturers has essentially been flat, at about $30 billion annually, from 2013 to 2017, with even that figure masking considerable declines from 2014 to 2016, as Figure 1 shows.

There is some evidence that these middling R&D investments in industrial manufacturing are contributing to middling innovation outcomes in U.S. manufacturing. For instance, according to the National Science Foundation, while the aggregate number of patents awarded to U.S. manufacturing enterprises increased by 54 percent from 2008 to 2017, the share of patents awarded to companies in the U.S. manufacturing sector compared to all companies declined from 72.7 percent to 67.5 percent over that time period, suggesting a relative weakening in U.S. manufacturing innovation activity relative to other sectors over that time period.[8] Similarly, Deloitte's study found that, while U.S. manufacturing sector patent activity grew at a compound annual growth rate of 8 percent from 2009 to 2017 (Figure 1), U.S. manufacturing patent activity "has plateaued since 2015," with innovation intensity, or patents granted per billion dollars of R&D spend essentially flat since 2015.[9]

FIGURE 1. Patents Granted and Industrial Spend by U.S. Industrial Manufacturers, 2009-2017[10]



Putting all this together helps explain why U.S. manufacturing productivity has lagged so substantially in recent years. Specifically, while U.S. manufacturing multifactor productivity (MFP) increased by an average of 2 percent per year from 1992 to 2004, it declined by an average of 0.3 percent per year from 2004 through 2016.[11] Likewise, as the U.S. Bureau of Labor Statistics recently noted, U.S. manufacturing sector productivity increased just 0.5 percent over the five years from 2011 to 2016, which was "well below the growth rate of 3.2 percent from 1987 to 2016."[12]

Other metrics signal weakness in the U.S. manufacturing sector. The number of U.S. manufacturing jobs decreased by 25 percent from 2000 to 2012, more than twice the decline experienced between the post–WWII peak in manufacturing employment, reached in 1979, and 2000.[13] Likewise, from January 2015 through January 2020, U.S. manufacturing employment grew at just 0.9 percent annually, compared to 1.9 percent across the rest of the economy.[14] Also, over that timeframe, while manufacturing wages did rise, at 2.2 percent annually, this was weaker than the 2.8 percent increase enjoyed by U.S. workers across the rest of the economy.[15] Meanwhile, in terms of trade, America's annual manufacturing trade deficit increased from $413 billion in 2019 to $794 billion in 2019, a 92.5 percent increase (65.7 percent in inflation-adjusted terms).[16] Similarly, in terms of trade in advanced technology products—the most sophisticated products from industries such as life sciences, medical devices, optoelectronics, IT, aerospace, and nuclear power equipment—the United States ran an all-time high trade deficit of $132 billion in 2019, down from a $4.5 billion trade surplus in 2001.[17]

U.S. manufacturing has still failed to recover from, or match relative output levels from before, the Great Recession. For instance, U.S. manufacturing has fallen from 13 percent of GDP in the first quarter of 2006 to 11.5 percent of GDP in the third quarter of 2019, meaning that manufacturing is just 88 percent as large a share of the economy now as it was in 2006 (see Table 1).[18] However, this decline has been far from uniform: Manufacturing of nondurable goods is only 71 percent as important to the economy now as it was in 2006, while manufacturing of durable goods is 105 percent as important. The growing importance of durable goods manufacturing has been primarily driven by computer and electronics manufacturing, which has

Table 1: Manufacturing Industries' Share of U.S. GDP, 2006 and 2019[19]

Industry	Percent GDP 2006 Q1	Percent GDP 2019 Q3	2019 Share of 2006
Manufacturing	**13.0%**	**11.5%**	**88%**
Durable goods	**6.2%**	**6.5%**	**105%**
Wood products	0.2%	0.2%	96%
Nonmetallic mineral products	0.3%	0.3%	74%
Primary metals	0.4%	0.4%	111%
Fabricated metal products	1.0%	0.7%	75%
Machinery	0.9%	0.7%	77%
Computer and electronic products	0.9%	1.8%	194%
Electrical equipment, appliances, and components	0.4%	0.3%	84%
Motor vehicles, bodies and trailers, and parts	0.9%	0.7%	87%
Other transportation equipment	0.7%	0.8%	112%
Furniture and related products	0.3%	0.1%	50%
Miscellaneous manufacturing	0.5%	0.5%	101%
Nondurable goods	**7.0%**	**5.0%**	**71%**
Food and beverage and tobacco products	1.6%	1.3%	81%
Textile mills and textile product mills	0.2%	0.1%	55%
Apparel and leather and allied products	0.1%	0.0%	49%
Paper products	0.5%	0.3%	55%
Printing and related support activities	0.3%	0.2%	71%
Petroleum and coal products	1.9%	1.0%	56%
Chemical products	2.2%	1.7%	76%
Plastics and rubber products	0.5%	0.4%	81%

nearly doubled from 0.9 to 1.8 percent of GDP over this period. In contrast, the apparel and leather, furniture, textiles, paper, and petroleum and coal industries have dragged the manufacturing sector down, all of which have contracted by more than one-third as a share of GDP.

While it's too early to predict the long-term impact of the COVID-19 crisis on the U.S. manufacturing sector, the short-term effects have been profound. In March 2020, U.S. manufacturing output fell by 6.3 percent compared to the prior month, which represented the sharpest monthly decline since World War II.[20] Similarly, the Empire State Manufacturing Survey for April 2020 plunged to a record low of -78.2.[21] The crisis will likely lead businesses and policymakers to reevaluate the construct of global supply chains in key manufacturing sectors such as pharmaceuticals and semiconductors. While the construct of global supply chains historically has focused largely on efficiency and cost-driven comparative advantages, there will likely be a greater focus placed on resiliency going forward. Similarly, calls have already come forward from many in the Congress and administration to assess whether the United States is exposed to key dependencies and reliance on foreign suppliers for critical goods and inputs in health and drug supply chains (such as for active pharmaceutical ingredients). For instance, one provision of the Coronavirus Aid, Relief, and Economic Security Act (the '"CARES Act") calls upon the National Academies of Sciences, Engineering, and Medicine to undertake an assessment of the security of the U.S. medical supply chain.[22] It's just one manufacturing subsector where the coronavirus crisis will likely embolden a push by policymakers to repatriate more manufacturing activity to U.S. shores.

Regardless, what the coronavirus crisis reaffirms is that America's manufacturing sector remains vitally important. In 2018, America's approximately 250,000 manufacturers contributed $2.3 trillion to America's economy, accounted for $1.4 trillion in exports (with 27 percent growth in manufacturing exports from 2010 to 2018), and employed 12.7 percent of the U.S. workforce.[23] Moreover, despite only accounting for 11 percent of U.S. GDP, the sector regularly accounts for about two-thirds of total U.S. business investment in R&D, accounting, for instance, for $271.3 billion, or 63 percent, of business R&D investment in 2018.[24] Likewise, America's manufacturing sector employs 33 percent of the country's scientists and engineers, with 7.6 percent of U.S. manufacturing workers employed in science and engineering occupations.[25] In other words, U.S. manufacturing remains vitally significant and in some cases vibrant, but it's nevertheless underperforming its promise, and so comprehensive strategies are needed—at both the federal and state levels—to enhance America's manufacturing potential.

STRATEGY AND POLICY FOR AMERICAN MANUACTURING

Policymakers at both federal and state government levels are positioned to enact a multitude of policies that could enhance American manufacturing competitiveness and growth. The following sections present a suite of policy recommendations addressing strategy and analysis, technology development and diffusion, finance, tax, and talent, considerations.

Manufacturing Competitiveness Analysis and Strategy

A number of countries have articulated coherent national manufacturing strategies.[26] Several recent examples include Germany's "High-tech Strategy 2025," Sweden's "Smart Industrialization Strategy," the United Kingdom's "Industrial Strategy," and China's "Made in China 2025 Strategy."[27] These manufacturing strategies perform functions such as undertaking a competitive assessment of the strengths and weaknesses of manufacturing sectors (including in terms of industrial commons and supply chains), promoting manufacturing technology

development and diffusion, directing government R&D funding to support industrial sectors, supporting workforce education, providing technical assistance to small to medium-sized enterprises (SMEs,) and coordinating federal- and state-level manufacturing-promotion activities.[28] And when it comes to digital manufacturing (sometimes referred to as "Industry 4.0"), at least 20 countries have launched digital industrial policies.[29]

The Trump and Obama administrations have introduced U.S. advanced manufacturing strategies.[30] But Congress should formalize this practice, by introducing legislation that would require Presidential administrations to quadrennially introduce a renewed U.S. manufacturing strategy. The White House should reply on proven inter-agency coordination mechanisms to enroll departments such as the National Economic Council (NEC), Office of Science and Technology Policy (OSTP), and the Office of Management and Budget (OMB), in development of the national manufacturing strategy. Senators Coons (D-DE), Merkley (D-OR), Rubio (R-FL), and Young (R-IN) have called for this as part of their Global Economic Security Strategy Act of 2019.[31]

However, more fundamentally, the U.S. government lacks the institutional capacity to undertake an ongoing and comprehensive assessment of U.S. manufacturing competitiveness. Thus, Congress should charter the creation of a new traded sector analysis unit within the federal government.[32] The unit could be housed within the National Institute of Standards and Technology (NIST) at the U.S. Department of Commerce (DoC). It would generate sector-based assessments, based on understanding global industry structure and performance and how the U.S. fares (e.g., key U.S. establishments including final producers and suppliers as well as global market share trends); understanding product/market segments as well as key internal competitive elements (such as cost structure, product attributes, flexibility, speed to market, and innovation); and external factors (e.g., R&D and training institutions, financial capital performance, and trade/professional organizations).[33] This unit would play a prominent role in developing the quadrennial federal manufacturing strategies. The Department of Commerce's Economic and Statistics Administration (ESA) should facilitate coordination across all appropriate assets within DoC—including the Bureau of Industry and Security (BIS), International Trade Administration (ITA), Bureau of Economic Analysis (BEA), and NIST—in developing such analyses.

States would also benefit from developing and executing state-level manufacturing innovation strategies. In 2018, the State Science and Technology Institute (SSTI) and the Center for Regional Economic Competitiveness (CREC), supported by NIST's Manufacturing Extension Partnership (MEP), launched a novel Policy Academy designed to assist states with developing and refining strategies impacting their manufacturing industries.[34] The following 14 states have participated across two Policy Academy cohorts: Arizona, Colorado, Illinois, Kentucky, Maine, Maryland, Missouri, New Jersey, North Carolina, Pennsylvania, Puerto Rico, Utah, Vermont, and Wisconsin.[35] While this represents a step in the right direction, federal support could go further; specifically by Congress authorizing a program, which could be administered by MEP, providing a grant of up to $300,000 per state—which would have a 2:1 federal-state matching requirement—to assist U.S. states with the development and execution of state-level manufacturing strategies. A requirement for receipt of federal funding, for this or other state-level, federally funded manufacturing support programs, should be state and local legislative reform to prohibit the use of all federal dollars for inter-state private-firm relocation subsidies, a "net-loss game" estimated to amount to as much as $70 billion annually in foregone tax revenue.[36]

Because manufacturing enterprises are often the economic anchors in rural areas of the United States, as well as major components of state manufacturing sectors, state-level manufacturing strategies should pay particular attention to addressing the needs and challenges faced by rural manufacturers. For instance, as the following figures show, 10 states, primarily in the Great Lakes region and Southeast, have more than 1,700 manufacturing enterprises; in 20 states, primarily along the Ohio and Mississippi River valleys and in the upper Great Plains, rural manufacturers represent more than 28 percent of all manufacturers, and in nine states more than 42 percent. (See Figures 2 and 3).

FIGURE 2. Rural Manufacturers as a Percent of Total Manufacturers per U.S. State [37]

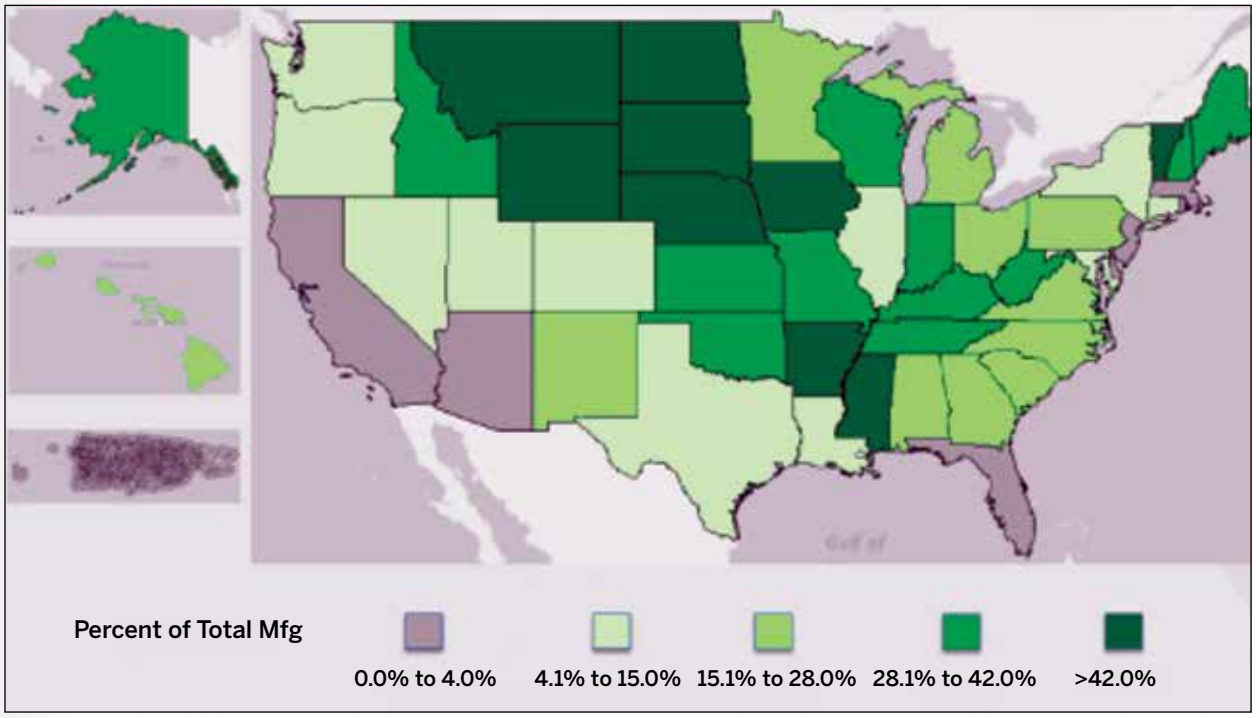
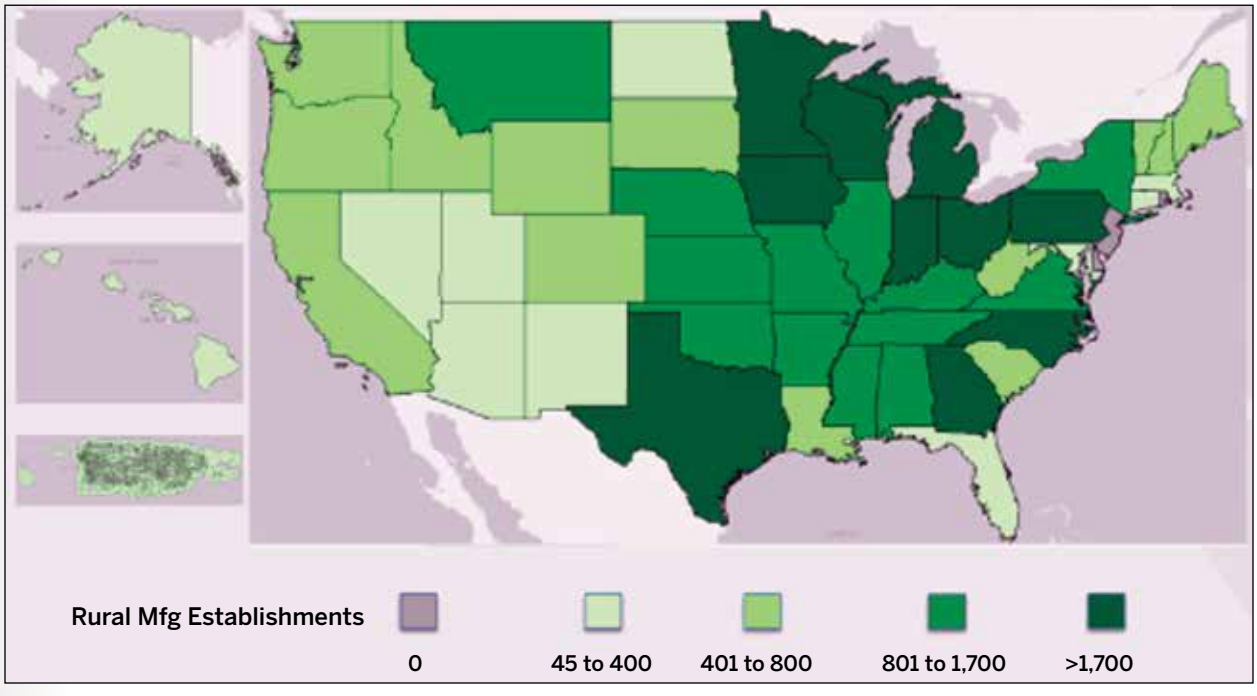


FIGURE 3. Rural Manufacturers per U.S. State[38]



While the ability to analyze industrial competitiveness is needed at the national level, and while states need to think holistically about their manufacturing capacity, strengths, and weaknesses, similar assessments need to take place at the regional or cluster levels.[39] This was the objective of the Investing in Manufacturing Communities Partnership (IMCP) program, initially launched during the Obama administration, which provided grant awards to communities that demonstrate best practices in attracting and expanding manufacturing by bringing together key local stakeholders and using long-term planning that integrates targeted public and private investments across a community's industrial ecosystem to create broad-based prosperity.[40] The IMCP program invested over $23 million to support 49 IMCP projects across 26 states, and it's estimated that IMCP-supported projects to date have saved more than 1,080 jobs and generated nearly $855 million in private investment.[41] The proposed Made In America Manufacturing Communities Act would extend the success of IMCP by authorizing a public-private program to enhance the way the United States leverages federal economic development funds to encourage American communities to focus not only on attracting individual investments one at a time, but also on transforming themselves into globally competitive manufacturing hubs.[42] While the current administration has not carried the IMCP program forward, the FY 2019 National Defense Authorization Act did allocate $20 million for a Defense Manufacturing Communities Support Program (DMCSP) initiative which seeks to "make long-term investments in critical skills, facilities, research and development, and small business support in order to strengthen the national security innovation base by designing and supporting consortiums as defense manufacturing communities."[43] Congress should allocate $50 million annually to support both the DMSCP and IMCP initiatives.

Another facet of analysis and intelligence related to community-level manufacturing strengths and weaknesses pertains to industrial retention efforts, particularly attempts to identify at-risk manufacturers and intervene with rapid business or technical assistance. For instance, Pennsylvania leverages 13 indicators (especially wage and tax data) to identify struggling manufacturers and proactively reach out with technical assistance programs, such as MEP interventions.[44] As one example, Pennsylvania's Steel Valley Authority (SVA) implemented the Strategic Early Warning Network (SEWN), a successful layoff aversion initiative with five offices that integrates into the commonwealth's overall dislocated worker services system. Since 1993, SEWN has engaged 1,100 at-risk SME manufacturers and averted or deferred the loss of 26,000 manufacturing jobs. SVA's SEWN is a model that could be more widely replicated across other states.

Finally, the coronavirus crisis, spawned in China and exemplifying key dependences on Chinese suppliers, shows how one critical aspect of the national manufacturing strategy should examine how critical, high-value manufacturing activities can be reshored to the United States. To that end, Congress should establish a reshoring incentive fund to provide financial support for firms in critical industries to relocate production now in China to the United States.[45] Here, one effective model the United States could learn from is Taiwan's three-year (2019-2021) "Action Plan for Welcoming Overseas Taiwanese Businesses to Return to Invest in Taiwan," which has helped Taiwan bring back at least 39,000 manufacturing jobs and NT$435 billion (US$14 billion) in manufacturing activity.[46]

Promoting Technology Development and Diffusion

Federal policy has vital roles to play in promoting the development and subsequent diffusion of advanced manufacturing technologies, particularly of the latter to SME manufacturers. Here, institutions and programs such as Manufacturing USA, the Manufacturing Extension Partnership

program, and the National Science Foundation's (NSF) Engineering Research Center (ERC) and Industry/University Cooperative Research Center (I/UCRC) programs play important roles.

Expand the Manufacturing USA Program

Manufacturing USA represents a network of 14 national manufacturing institutes that constitute public-private partnerships, jointly funded by government and private industry, focused on various advanced manufacturing product or process technologies.[47] The 14 institutes advance manufacturing R&D and innovation in fields such as additive manufacturing, digital manufacturing, clean energy manufacturing, advanced composites, lightweight materials, photonics, robotics, bio-fabrication, flexible materials, textiles, and other manufacturing technologies. The institutes engage partners in technology road-mapping exercises; conduct cutting-edge R&D; provide state-of-the-art facilities, equipment, and testbeds; train tomorrow's manufacturing workforce, in part by developing skills standards and certifications; and diffuse their learning across the Manufacturing USA network and to SMEs.[48]

To date, the institutes have received overall commitments of more than $3 billion, including $1 billion in federal funding, which has been matched by over $2 billion in nonfederal investments, including $400 million contributed by state governments. In 2018, Manufacturing USA conducted over 475 major applied R&D projects and provided workforce training to more than 200,000 workers, students, and educators.[49] So impactful has been Manufacturing USA that China copied America's first six Manufacturing USA Institutes institute-per-institute in order of introduction and copied exactly the first 14 institutes overall.[50] However, China hasn't stopped there, it's proceeding with plans to introduce 40 manufacturing institutes, just as the United States originally envisioned launching 45.[51]

The United States should continue to build out the Manufacturing USA network to the 45 institutes originally intended.[52] In March 2019, the Department of Energy announced that a 15th institute, focused on cybersecurity, would be launched.[53] But Congress should go further, authorizing $1 billion over five years to double the size of the Manufacturing USA network. Immediately, Congress and the administration should expand the Manufacturing USA network by adding several new institutes focused on biomedical manufacturing to address the coronavirus crisis. COVID-19 has revealed the dependence of the United States on imports of vital medical supplies. These new innovation institutes would aid in re-establishing state-of-the-art domestic capacity in fields like advanced medical equipment and active pharmaceutical ingredients, complementing the existing BioFabUSA and NIIMBL institutes. It's worth noting that NIST has opened a funding opportunity through its Manufacturing USA Institutes for rapid, high-impact manufacturing projects that support the nation's response to the COVID-19 pandemic.[54]

Another approach the administration could take to expand the Manufacturing USA network would be to leverage a provision included in the Revitalize American Manufacturing Innovation Act (2013 Congressional legislation which authorized Manufacturing USA) that would give the Secretary of Commerce the ability to designate as members of Manufacturing USA organizations that are substantially similar to existing institutes. Dubbed the "affiliates model," it could be used to bring existing, often regional, centers of manufacturing innovation—such as the Edison Welding Institute, Southwest Research Institute, South Carolina Research Authority, Commonwealth Center for Advanced Manufacturing (in Virginia), the Purdue Research Foundation, and others—within the Manufacturing USA rubric. Such centers would benefit from joining Manufacturing USA by having a platform to expand their national reach and by learning from other institutes' best practices and being better connected to the technologies they're developing. To enhance their impact, in the 2020 National Defense Authorization Act, Congress

appropriately eliminated the automatic five- to seven-year federal funding sunset for Manufacturing USA institutes, and replaced it with a five-year, metrics-based review program with minimum standards of performance focused on advancement of technology and manufacturing readiness.[55] While the federal share of Manufacturing USA institute funding should decline over time—institute value propositions need to principally work for and add value to industry—because the institutes play important public goods roles such as providing technology testbeds, supporting the industrial commons, developing skills standards and certifications, and contributing to workforce training, an ongoing federal share of funding should persist at about 20 to 25 percent of institute budgets (another incentive for affiliate institutes to join the network).[56]

Expand the Manufacturing Extension Partnership (MEP) Program

While Manufacturing USA focuses primarily on industrial R&D and technology development, the Manufacturing Extension Partnership plays a vital role in technology diffusion. MEP provides SME manufacturers with a wealth of unique resources centered on five critical areas: technology acceleration, supplier development, sustainability, workforce, and continuous improvement. The program operates 51 MEP Centers located in all 50 states and Puerto Rico, staffed by over 1,400 advisors at 375 service locations.

MEP delivers a significant return on investment for U.S. taxpayers.[57] In FY 2019, MEP helped manufacturers achieve $15.7 billion in sales, $1.5 billion in cost savings, $4.5 billion in new client investments, and helped to create or retain 114,650 U.S. manufacturing jobs.[58] An April 2018 study by the W.E. Upjohn Institute, "The National-Level Economic Impact of the Manufacturing Extension Partnership," likewise found that MEP generates a substantial economic and financial return, of nearly 15:1 for the $128 million annually invested by the federal government in the MEP program.[59] The study further found that total employment in the United States was over 219,000 individuals higher, U.S. GDP $22 billion larger, personal income $13.8 billion higher, and personal income tax revenue to the federal government $1.86 billion higher because of MEP center projects than it would be without the program.[60]

MEP touches about 25,000 U.S. SME manufacturers each year (a little less than 10 percent), but MEP could do so much more if it were more robustly funded. The reality is that the United States substantially underinvests in MEP relative to both its own historical norms and compared to investments made by competitor nations. MEP's budget in FY 2019, $140 million, was scarcely more than its 1998 budget of $113.5 million, meaning that, as a share of GDP, the United States invested almost twice as much in supporting its SME manufacturers in 1998 as it did in 2019.[61] Moreover, as a share of GDP, Japan invests 30 times more in its Kohsetsushi centers than the United States invests in its MEP; Germany invests approximately 20 times as much overall in its Fraunhofer centers; and Canada invests almost 10 times as much in its Industrial Research Assistance Program (IRAP).[62] Instead of zeroing out MEP (as has been the case in every budget proposed by the Trump administration), Congress and presidential administrations should align to increase MEP's annual funding to closer to $200 million annually, putting funding in line with historical norms. Additional federal funding would allow MEP centers to develop more programs helping companies scale up from lower- to higher-volume production and get innovative products to market faster. While the CARES Act did laudably allocate $50 million to the nation's 51 MEP centers to support the economic recovery of SME manufacturers hurting from the impact of COVID-19, this should be viewed only as a stopgap and long-term funding for the MEP centers needs to be stepped up.[63]

Another opportunity for MEP growth is that, because supply chains cross state boundaries, MEP needs to develop more cross-state, sector-based MEP initiatives (e.g., MEP programs designed to support the automotive sectors in the U.S. Midwest and Southeast). In other words, MEP should take on more of a supply chain and sector-based focus, making the program more oriented around America's industrial clusters. Here, MEP has developed an explicit supply-chain optimization (SCO) initiative designed to help manufacturers build dynamic supply chains by developing a long-term strategy, increasing visibility throughout multiple supplier tiers, identifying and mitigating risks, identifying enterprise resource planning systems that are compatible across supply chain tiers as well as affordable for SMEs, and understanding total cost of ownership (TCO) and other best practices that encourage strategic partnerships throughout the supply chain.[64]

Another approach a number of MEP centers have taken is to not wait for manufacturers to come to them, but to go out into the field and proactively bring automation technologies to manufacturers. For instance, in 2020, South Dakota's MEP began a state-wide roadshow, going into the field to demonstrate how rural manufacturers could more effectively deploy cobots. The initiative represents an offshoot of the successful Automation Lab launched in Sioux Falls in 2015 which allows manufacturers to see first-hand how collaborative robots interact with people while providing a beta test for specific applications.[65] Pennsylvania has a similar initiative demonstrating the potential of additive manufacturing technologies for small manufacturers in defense supply chains.[66]

Digital manufacturing enables manufacturers to converge the physical and digital worlds, combining sophisticated hardware with innovative software, sensors, connectivity, and massive amounts of data and analytics to produce smarter products, more efficient processes, and more closely linked customers, suppliers, and manufacturers.[67] Companies implementing digital manufacturing are realizing up to 25 percent improvements in productivity and 40 percent faster innovation and time-to-market speeds.[68] But digitalization represents a significant challenge, especially for SME manufacturers, who often don't know where or how to begin or what the value proposition of digitalization will be. That's why a key product of Germany's Industry 4.0 efforts has been the identification of over 300 "use cases" explicitly detailing how Germany's manufacturers, on a sector-by-sector basis, can digitalize their production processes.[69] Similarly, MEP should develop and make nationally available both "Digital Manufacturing and Design Maturity" and "Cybersecurity Maturity" assessment tools that help manufacturers identify and close gaps in their digital workflow and chart a path for their manufacturing digitalization journey.[70] The coronavirus crisis only further animates the need to encourage greater U.S. manufacturing digitalization, which ensures effective cybersecurity practices. For instance, a March 2020 survey of its members by the National Association of Manufacturers found 53 percent stating that it would force a change in their manufacturing operations (and 35 percent stating it would disrupt their supply chains).[71] As ITIF explains in its report, "Digital Policy for Physical Distancing: 28 Stimulus Proposals That Will Pay Long-Term Dividends," from robotics, to 3D printing, to AI and IoT, greater adoption of digital manufacturing and industrial automation practices stemming from the coronavirus crisis holds the potential to both enhance worker safety and bolster U.S. manufacturing productivity.[72]

Expand the Engineering Research Center and Industry/University Cooperative Research Center Programs

The National Science Foundation's Engineering Directorate operates two forms of industry-university partnerships: Engineering Research Centers and Industry/University Cooperative Research Centers. ERCs represent a group of interdisciplinary centers located at universities,

where academia and industry can collaborate in pursuing strategic advances in complex engineered systems and systems-level technologies that have the potential to spawn entirely new industries or to radically transform the product lines, processing technologies, or service delivery methodologies of current industries.[73] The I/UCRC program forges partnerships between universities and industry, featuring industrially relevant fundamental research, industrial support of and collaboration in research and education, and direct transfer of university-developed ideas, research results, and technology to U.S. industry to improve its competitive posture in global markets.[74]

Congress should increase funding for the ERC and I/UCRC programs and support the development of more manufacturing-oriented centers.[75] For instance, currently there are just two non-graduated advanced manufacturing-focused ERCs (one for biorenewable chemicals and one for nanomanufacturing systems for mobile computing and mobile energy technologies) whereas there are six ERCs for biotechnology and health care; seven for energy, sustainability, and infrastructure; and four for microelectronics, sensing, and IT.[76] To be sure, there are 12 graduated manufacturing-focused ERCs (meaning they have graduated from 10 years of NSF support and become self-sustaining), but NSF should be establishing more new manufacturing-focused ERCs. Similarly, only 8 of the 87 I/UCRCs are focused on advanced manufacturing research and technology development.[77] Yet the I/UCRC program delivers tremendous returns, with one study finding that each dollar invested into I/UCRCs generates an estimated $64.70 in economic impact.[78] The Engineering Research Centers received $58.95 million in FY 2019 funding. FY 2018 NSF funding for the I/UCRC program stood at $12.5 million, well below the level warranted for such an impactful program.[79] Congress should increase I/UCRC funding to $50 million annually and ERC funding to $100 million per year.

Bolster Financial Support Mechanisms to Stimulate Manufacturing Innovation

Policymakers can play a supportive role to introduce creative financial mechanisms that stimulate manufacturing innovation, particularly for SME manufacturers, but also for larger manufacturers to support scaling activities. Consider SME manufacturers first. From deploying digital manufacturing tools to more energy-efficient processes to innovating next-generation products, the potential for America's SME manufacturers is enormous, yet it's often held back due to a lack of sufficient capital. For instance, a recent McKinsey study found that fully one-quarter of SME manufacturers in America's mid-Atlantic region lacked the finances to even meet their working-capital needs.[80] Indeed, access to capital has generally been tighter for SMEs in the United States than in other Organization for Economic Cooperation and Development (OECD) countries since the Great Recession.[81] Morevoer, studies estimate that the inability of small firms to sufficiently invest in plant and equipment upgrades contributes considerably to their stark 40 percent productivity gap with larger firms.[82]

Other studies find that truly achieving the potential of digital manufacturing will require upgrading about 40 to 50 percent of the current asset base across U.S. manufacturing industries.[83] In particular, machinery will need to be upgraded or replaced to accommodate Internet of Things (IoT) sensors and actuators and new high-performance computing platforms will be needed to support advanced modeling and simulation as well as analytics to mine data sets.[84] This imperative will become all the more pressing as existing U.S. manufacturing plant and equipment continues to age. In fact, whereas the average U.S. factory was 16 years old in 1980, today it's 25 years old; likewise, whereas the average piece of plant equipment was seven years old in 1980, it's nine years old today.[85] Public policy should help identify ways manufacturers can close capital gaps for investments in manufacturing innovation.

Introduce Innovation Vouchers

One approach numerous U.S. states—including Connecticut, New Mexico, Rhode Island, and Tennessee—have deployed to assist SME manufacturers with financing innovative activity is innovation vouchers. Innovation vouchers are grants—generally redeemable at local universities, community colleges, or research institutions—that help SME manufacturers purchase the expertise needed to develop a new product or process. In most states, vouchers may be used for technological development or feasibility studies; product, service, or market development activities; access to research or scientific expertise; and in some states for the acquisition of or access to vital equipment or software. Most nations and U.S. states that have introduced innovation vouchers have experienced positive and impactful results. Reviews of similar programs in Austria and the Netherlands have found 80 percent additionality, meaning that a research project or innovation activity would not have been undertaken otherwise. Likewise, in the United States, reviews of state-level innovation voucher programs have found that the instrument has helped to engage new SMEs and to bring them into additional support programs, such as the Small Business Innovation Research (SBIR) or MEP programs; to have stimulated the development of new intellectual property and patenting activity; and to have boosted SMEs' hiring, revenue, and gross margins.[86] Similarly, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (EERE) operates a small business voucher program that has provided vouchers to 114 small businesses (including many clean-energy technology manufacturers) from 31 different states that are currently working with U.S. national labs.[87] Innovation vouchers work, but their national reach could be expanded. Accordingly, Congress should pass S.3289, the Small Business Innovation Voucher Act of 2020, as introduced by Senators Cortez-Masto (D-NV), Young (R-IN), and Coons (D-DE), which would authorize $10 million annually from 2021 to 2025 to enact a national innovation voucher program, operated out of the Small Business Administration (SBA), which would provide $25,000-$50,000 grants to small businesses to partner with an institution of higher education or research laboratory in the pursuit of commercialization or R&D activities.[88]

Create a 401(k) Program for Small Manufacturers

The state of Connecticut has experimented with a unique approach to help SME manufacturers bootstrap themselves. The concept is to essentially create a 401(K) program for small manufacturers that allows them to place up to $1 million into a tax-deferred, investable account but allow the money to only be withdrawn for subsequent investments in R&D, workforce retraining, or new plant and capital equipment. Congress could introduce legislation creating such a mechanism at the federal level, or the approach could be adopted by individual states.

Launch a Federal Loan Guarantee for Innovative Technologies in Manufacturing Program

The cost of implementing some digital manufacturing technologies has decreased in recent years. As Mike Coast and Bob Lyscas of the Michigan Manufacturing Technology Center (Michigan's MEP) explain:

> In some areas like smart sensors or robotics, the cost has been reduced by as much as 80 percent even over the past three years; what was costing in the area of $750,000 three years ago might be closer to $100,000 today. That lower cost is accelerating return on investment (ROI). For a 150-200 person-size company, we're seeing ROI within 1.2-2 years and on the larger size firms (200-500 employees) we're seeing good ROI data in the two to five-year timeframe.[89]

Nevertheless, due to intense working capital constraints, many small manufacturers are unable to make the upfront investments in upgraded technologies that could have positive ROI paybacks in as little as two years. That's why ITIF has suggested that Congress create a "U.S.

Manufacturing Digitalization Investment Fund" that would provide repayable, low-interest loans to American SME manufacturers to help finance upfront investment in digital manufacturing technologies and solutions. Similarly, Manufacturing Foresight, an Ann Arbor, Michigan-based, nonprofit organization focused on the future of U.S. manufacturing technology, policy, and the workforce, has likewise called for the U.S. government "to provide loan guarantees and technical assistance to accelerate the pace of modernization of SMMs, including capital equipment and implementation of smart manufacturing technologies."[90] In fact, the America COMPETES Reauthorization Act of 2015 actually created a mechanism for a Federal Loan Guarantee for Innovative Technologies in Manufacturing Program that could support manufacturers' adoption and commercialization of new technologies, although this authorization has not been formally stood up by the administration. Congress should formally authorize this program and appropriate $150 million annually to it; programmatically it could disburse the funds to states willing to provide a 1:1 match for the investment and to administer the program to manufacturers at the state level.

Restructure SBA Section 7(a) Loan Funding for Manufacturers

The U.S. Small Business Administration should focus more on manufacturing and other traded-sector firms through its financing programs, including its 7(a) loan guarantee program. However, the SBA does not appear to give any special priority or focus to traded-sector firms, such as manufacturers, treating all industries alike in its funding priorities, in large part because this has been SBA's charge from Congress. In fact, today, only 7.5 percent of SBA loans go to small manufacturers.[91] To reform SBA lending more toward manufacturers, Congress could enact S.347, the Investing in America's Small Manufacturers Act, as proposed by Senators Gardner (R-CO) and Coons (D-DE). The Act would increase the maximum 7(a) loan guarantee rate for manufacturers to 90 percent and allow certified development companies to offer up to 50 percent of project financing through the 504 loan program, which is fully guaranteed by the SBA. The legislation would further reduce the guarantee fees that small manufacturers are required to pay on 7(a) loans by eliminating 7(a) guarantee fees for small manufacturers on loans less than $350,000 and by reducing fees by half on loans in excess of that amount.[92] The SBA recently adopted a similar loan guarantee fee reduction for veteran-owned businesses, after which SBA loan volumes to those businesses increased by 100 percent.

Establish Manufacturing Scaling Programs and Initiatives

Demonstration and scale-up represent major gaps in the U.S. manufacturing innovation system. Demonstration refers to the generation of credible cost and performance information that informs early adopters in commercial markets, particularly for complex, large-scale systems; while scale-up refers to the rapid growth of production facilities, such as for modular energy hardware technologies. As former Intel CEO Andy Grove has noted, while the United States has excelled at inventing new technologies (e.g., microprocessors, solar cells, rechargeable electric batteries, etc.), in many cases it has been less successful in scaling production of these technologies and capturing high levels of global market share (which is where the profits are made from new technologies).[93] Indeed, a study of manufacturing technology-intensive start-ups spun out of the Massachusetts Institute of Technology (MIT) found that almost all that scaled up into commercial production did so overseas, largely because of some foreign countries' more attractive capital and investment environment for manufacturing start-ups.[94] The research found that while the startup firms were able to raise U.S.-based venture capital for their early stages of development, outside of the biotechnology sector they encountered difficulty finding the large sums of capital required to scale up their manufacturing activities. Yet they often found willing partners in Asian countries that were willing to provide grants to attract later-stage manufacturing products and that often provide guarantees in terms of demand.[95] As William

Bonvillian and Peter Singer write in their book *Advanced Manufacturing: The New American Innovation Policies*, this highlights the case that America needs an "invent here/make here" approach.[96]

To address these challenges, Congress could create a program to facilitate public-private investment partnerships, allowing private investment firms to leverage funds provided by the government to help emerging manufacturers commercialize their products. For instance, Senator Booker (D-NJ) has proposed a Scale-Up Manufacturing Investment Company (SUMIC) Act, modeled on the SBA's Small Business Investment Company (SBIC) program, that would allow participating investment firms to invest in securities and issue debentures to raise capital that would then be used by manufacturers to finance their scale up of prototypes to commercial-scale facilities in the United States.[97]

Other countries use a similar approach, and one model the United States could emulate here is Germany's KfW Bank. KfW is a government-owned development bank, established at the end of World War II at the urging of the Allies to help reconstruct the war-torn German economy. The bank raises funds in part through issuing government-backed bonds. While it does fund some housing, especially energy-efficient housing, it also provides export financing and funding for SME manufacturers.

Another approach Congress could consider would be authorizing the Export-Import Bank to go beyond providing export credit financing by leveraging the resources of the Bank to help create domestic manufacturing jobs. In particular, Congress could allow the Export-Import Bank to use $20 billion in unobligated authority to lend directly to domestic manufacturing companies that are in competition with subsidized foreign competitors (e.g., competitors who receive subsidies in the form of grants, subsidized loans, special tax treatment, beneficial land use, etc.). The loan recipients would need to be able to demonstrate how the funds would support their expanded manufacturing activities and employment in the United States.[98]

Policymakers could also look to amplify and expand existing manufacturing scaling programs that universities, national laboratories, and regional incubators have experimented with developing. For instance, MIT's "The Engine" builds on MIT's interest in bringing together technology start-ups, large companies, biopharma companies, federal labs, local incubators, and SME manufacturers in the region. It aims to fill a critical emerging gap in the innovation system, offering space, technology, and know-how as a substitute for initial financing, then de-risking and accelerating new technologies so they can come into range of existing financing opportunities. The Engine is regionally based but offers a new model for other universities and regions interested in bridging such innovation gaps.[99]

A related example is a partnership between the Massachusetts MEP and Greentown Labs, a nearby incubator, which in November 2014 partnered to launch a pilot program called the Greentown Labs-MassMEP Manufacturing Initiative, aimed at linking Massachusetts start-ups with local manufacturing capabilities. During the pilot, members of Greentown Labs and MassMEP identified the existing barriers that prevent start-ups and established SME manufacturers from working together and developed a program to systematically address those challenges. The Greentown Labs-MassMEP Manufacturing Initiative offers a framework for start-ups in the later stages of incubation (or, if they have venture support, early stages of series-A funding) to connect to local manufacturers and take their prototype to a production-ready design.[100]

Strengthen Tax Incentives to Stimulate Manufacturing Innovation

The United States has made some strides in recent years toward implementing a more globally competitive corporate tax code, including by lowering the corporate tax rate from 35 to 21 percent and by moving toward a territorial system for corporate taxation as part of the Tax Cuts and Jobs Act (TCJA) of 2017. However, in other areas, the United States has moved backwards. Whereas in 1981 it introduced and for many years offered the world's most generous R&D tax incentive, today the United States has fallen to 30th in the OECD for R&D tax incentive generosity.[101] Moreover, the TCJA eliminated firms' ability to write off research expenses in the first year starting in 2022, meaning companies conducting R&D will pay more taxes, not less, with the net effect expected to be a nearly $8 billion increase in the after-tax cost of R&D.[102]

Congress could take several steps to reform the tax code to stimulate investment in manufacturing research and innovation, including providing more generous tax credits for investments in new machinery and equipment, making R&D tax incentives more generous, and introducing a collaborative R&D tax credit.

Provide a More Robust Tax Credit for Investments in New Machinery and Equipment

Despite the 2017 tax reform (which did constructively provide for expensing of investments for five years), Congress could provide an even stronger tax incentive for investment in machinery and equipment. Specifically, Congress should enact an investment tax credit (ITC) providing a 25 percent credit on all capital expenditures made above 75 percent of a base amount.[103]

Make the R&D Tax Incentive More Generous

Congress could build on the 2017 tax bill by doubling the Alternative Simplified Credit (ASC) to 28 percent. Under the ASC, companies are credited 14 percent of the difference between their current research spending and half of their average research spending over the last three years. The idea is to provide an incentive for companies to keep ratcheting up their investments in research. To make the credit an even stronger engine for R&D investment in the United States, Congress should at least double the rate (to 28 percent).[104] Doing so would create jobs, innovation, and GDP growth. In 2010, ITIF estimated that changing the credit to just 20 percent would create 162,000 jobs and generate 3,850 additional patents each year, while increasing productivity by 0.64 percent and GDP by $66 billion per year. In real, net-present-value terms, the taxes from this increased economic activity would balance the revenue loss within 15 years.[105]

Introduce a Collaborative R&D Tax Credit

Over the last two decades, firms have increased their collaborations with institutions, particularly universities, in order to lower the cost of research and increase its effectiveness by maximizing idea flow and creativity. Recognizing this, at least a dozen nations have established collaborative R&D tax credits designed to incentivize industry investment in collaborative research, especially at universities.[106] The United States actually has a collaborative R&D credit, but only for the energy sector: as part of the Energy Policy Act of 2005, Congress created an energy research credit that allows companies to claim a credit equal to 20 percent of the payments to qualified research consortia for energy research. Congress should allow firms to take a flat credit of 20 percent for all collaborative research undertaken in conjunction with universities, research institutes, federal laboratories, or multi-firm consortia.[107] Congress has considered this before; in fact, several bills have been proposed which would make all research consortia, not just energy-related ones, eligible for a 20 percent credit.[108]

Introduce a U.S. Competitiveness Tax Credit

While the above tax recommendations represent solid discrete steps, the coronavirus crisis may spur bolder action. Congress could go further by establishing a Competitiveness Tax Credit, providing a tax credit of 45 percent of all business investments made in the United States in R&D, skills training, and global standards setting, and a 25 percent credit for expenditures on new equipment and software, with expenditures in excess of 75 percent of base-period expenditures qualifying for the credit.[109]

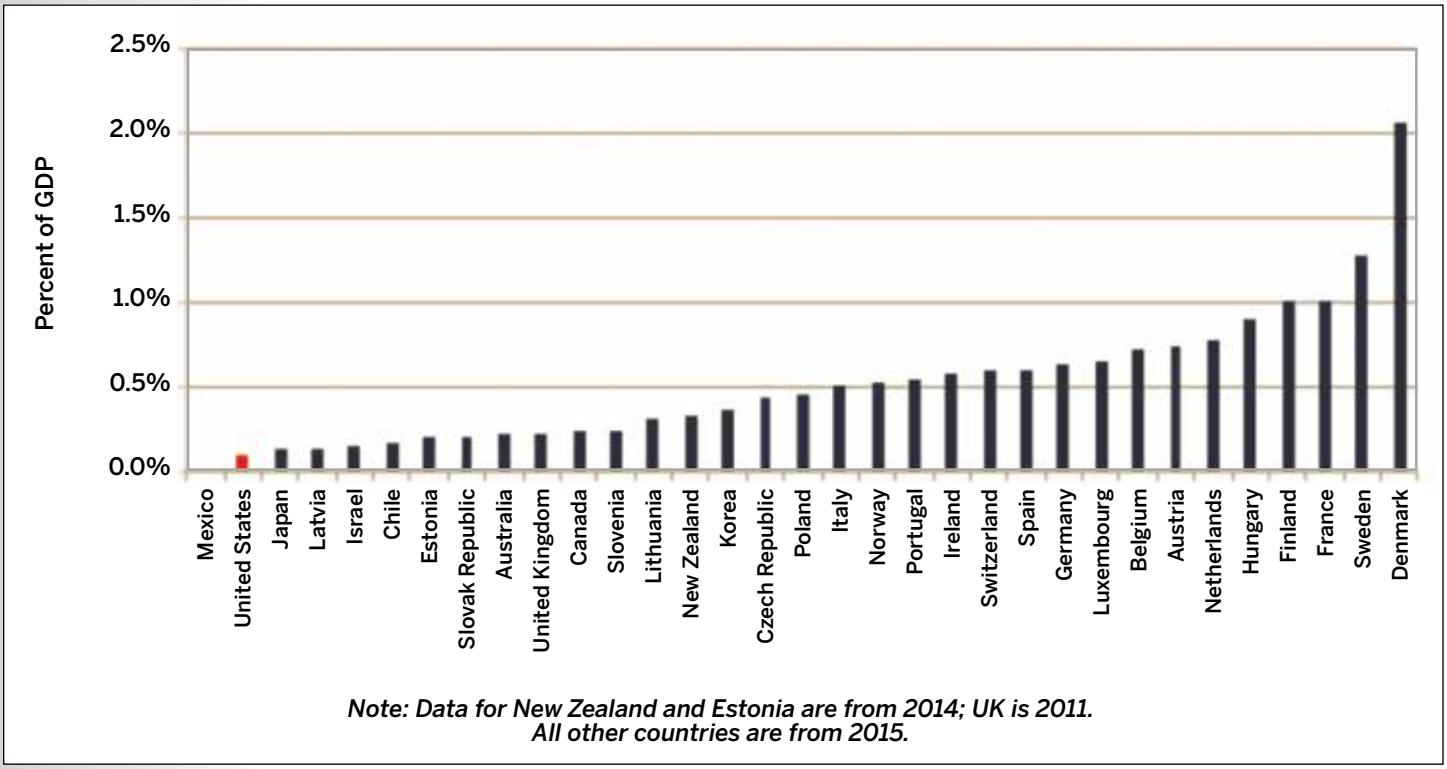
Support Manufacturing Workforce Education and Skills Development

The United States could do much more to strengthen education and skills development for its manufacturing workforce, both with regard to workers who are graduating from high schools, universities, and community colleges and with regard to those who are already in the manufacturing workforce and in need of upskilling. The following section offers several proposals policymakers could undertake to strengthen skills development for America's manufacturing workforce.

Increase Investment in Workforce Training Programs

The United States significantly underinvests in workforce training programs.[110] In fact, the United States dedicates just 0.1 percent of GDP to active labor market programs, as compared to the OECD average of 0.6 percent of GDP, meaning America's OECD peers like Austria and Germany invest six or more times more in their workforce training and support programs than does the United States (Figure 4).[111]

FIGURE 4. Public Expenditure on Active Labor Market Programs (% of GDP)[112]

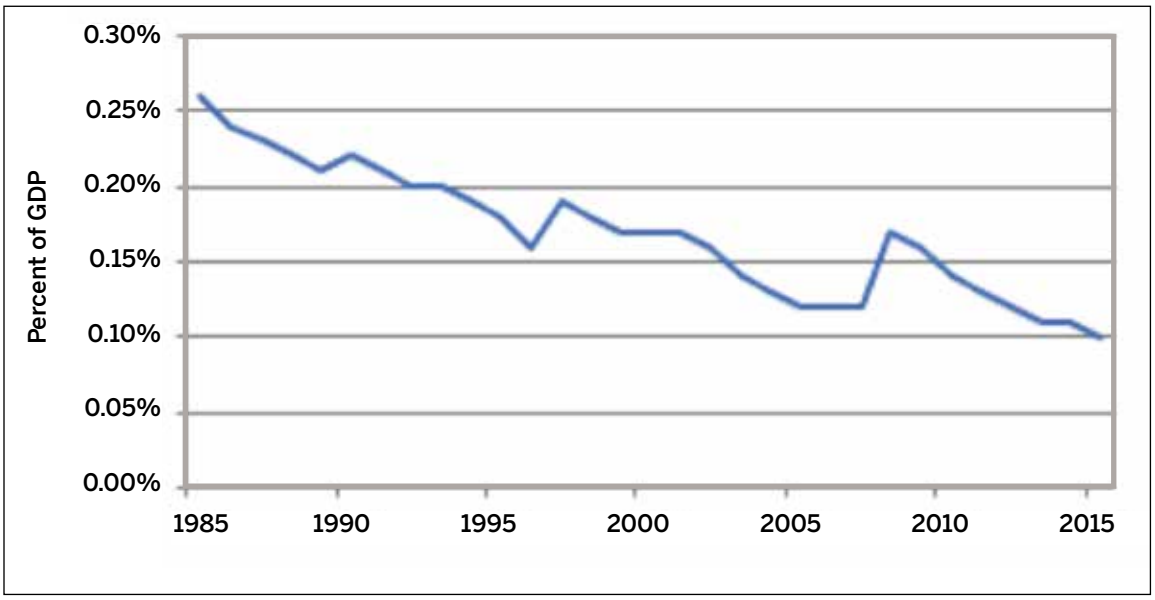


Note: Data for New Zealand and Estonia are from 2014; UK is 2011. All other countries are from 2015.

Moreover, the United States now invests less than half of what it did on such programs 30 years ago, as a share of GDP (Figure 5).

Congress should bring the United States up to the OECD average for investments in labor market training programs, meaning the United States would need to invest at least six times more in such programs annually.

FIGURE 5. U.S. Public Expenditure on Active Labor Market Programs as Percent of GDP[113]



Establish a Grant Program Empowering Advanced Manufacturing Education at Community Colleges

Austria's Wirtschaftsförderungsinstitut ("WiFi"), or Institute for Economic Promotion, is a department of the Austrian Federal Economic Chamber which specializes in vocational training and adult further education for the advancement of lifelong learning. With WiFi facilities in each of Austria's nine provinces, it represents the largest adult worker training institute in Europe, offering 27,000 courses, seminars, and programs and serving over 500,000 Austrians each year.[114] Essentially, Austrian workers can visit WiFi Centers to upskill themselves for any number of advanced manufacturing technologies and applications, from learning to work with robots, IoT applications, or even how to code for or understand the output of artificial intelligence or machine learning-based systems. Austria's WiFi network represents arguably the world's most-advanced worker retraining/upskilling system.

The United States needs a similar approach, although given America's unique system, it would be more appropriate to amplify the ability of U.S. community colleges to fulfill this role. One place to start would be to reduce the funding gap between four-year universities and two-year public institutions such as community colleges. As Richard Kahlenberg observes in a report for the Century Foundation, "the total federal, state, and local appropriations and tax subsidies per full-time equivalent student is $41,100 at private high-endowment institutions, $15,300 at public flagship institutions, $6,700 at public regional institutions, and $5,100 at community colleges."[115] And direct public spending per student is almost twice as much at public research universities as at two-year community colleges. For instance, Kahlenberg cites a Brookings Institution study showing that "four-year institutions received nearly three times as much federal aid ($2,600 per student, including financial aid) as community colleges ($790)." Policymakers in both federal and state governments should adjust funding programs to reduce these gaps in support between students attending four-year universities and two-year community colleges.

But community colleges will also need to reimagine their curriculum and relationships with manufacturers to position themselves for development of new skills required in advanced manufacturing. A good example of a community college that has done so is Tennessee's Motlow State Automation and Robotics Training Center (ARTCm).[116] ARTCm represents a collaborative effort co-funded by the Tennessee state government, local industry, and philanthropic supporters

which offers robotics industry-recognized training credentials/certificates and robotics degrees programs such as mechatronics degrees with a concentration in robotics. ARTCm represents a model that could be implemented nationwide; there should be 40 such centers across the United States. Congress should designate minimum standards for the establishment of two-year, advanced manufacturing-focused community college programs in the United States and establish a $100 million fund which states could apply for to use those funds for acquisition of equipment, development of curriculum, and recruitment of faculty at such community colleges.

Expand the Use of Industry-Recognized, Nationally Portable Skills Standards

The United States could better facilitate the movement of skilled workers if specific manufacturing skills standards, for example for welders, were more readily recognized and accepted across state lines.[117] Congress and the administration should work to increase credentialing for manufacturing industry workforce members by expanding the use of standards-based, nationally portable, industry-recognized certifications specifically designed for specific manufacturing sectors, such as those developed by the Manufacturing Skill Standards Council (MSSC) and supported by the National Association of Manufacturers-endorsed Manufacturing Skills Certification System. In particular, the Secretary of Labor and the Secretary of Education, in conjunction with the Secretary of Commerce, should ensure that industry-approved certification standards are established and available nationwide to providers of manufacturing and logistics education and training programs by providing the funding needed to fully establish and deploy this initiative.

Expand Tax Benefits for Employer-Funded Tuition Assistance

U.S. corporate investment in workforce training has declined significantly over the past two decades. Corporate investment on training as a share of gross domestic product declined from more than half a percent in 2000 down to one-third of a percent in 2013.[118] As the Economic Report of the President finds, the proportion of workers that received employer-sponsored training dropped 42 percent between 1996 and 2008.[119] To address these challenges, Congress should take two steps. First, Congress should expand Section 127, which provides tax benefits for employer-provided tuition assistance, especially because the eligible amount ($5,250 per year) has not increased since 1996. Specifically, Congress should increase Section 127 to at least $8,700 (accounting for the rate of inflation since 1996) and index the amount to the annual rate of inflation going forward. Congress could also expand Section 127 to include coverage for career counseling activities. Second, Congress should consider turning the R&E credit into a knowledge tax credit by allowing qualified expenditures on both R&D and workforce training to be taken as a credit and expanding the rate from 14 percent to at least 20 percent.

Extend the Manufacturing Engineering Education Program

The Manufacturing Engineering Education Program (MEEP) was signed into law in December 2016 as part of the 2017 National Defense Authorization Act, authorizing the Department of Defense to support industry-relevant, manufacturing-focused, engineering training at U.S. institutions of higher education, universities, industry, and not-for-profit institutions.[120] In 2018, the U.S. Department of Defense issued several MEEP awards, launching the initiative.[121] The program was derived from a 2012 ITIF proposal that the United States should create a core of at least 20 universities that brand themselves as leading manufacturing universities.[122] ITIF proposed that universities would revamp their engineering programs and focus much more on manufacturing engineering and in particular work that is more relevant to industry. MEEP essentially represents a pilot program exploring the proposal; the program received an initial appropriation of $10 million in fiscal year 2017 and $15 million more in FY 2019.[123] Congress

should significantly broaden the Manufacturing Engineering Education Program, providing at least $100 million in funding and establishing programs at 20 universities.

Expand Funding for NSF's Advanced Technology Education Program

Skilled technicians represent a key component of America's manufacturing workforce. One highly successful program designed to build technician skills is NSF's Advanced Technological Education (ATE) program, which supports community colleges working in partnership with industry, economic development agencies, workforce investment boards, and secondary and other higher education institutions. Since its inception in 1994, the program has made 265 manufacturing awards totaling $205 million.[124] ATE projects and centers are educating technicians in a range of fields, including nanotechnologies and microtechnologies, rapid prototyping, biomanufacturing, logistics, and alternative fuel automobiles. Notwithstanding this, ATE funding is quite small, at around $75 million per year. Congress should expand funding for the ATE program, doubling it to at least $150 million annually.

Funding Competitiveness and Manufacturing Support Policies and Programs

To be sure, the policy proposals called for in this report would require significant investments, and a legitimate question is where would funding for such investments come from. ITIF has long argued for the United States to more aggressively confront Chinese innovation mercantilism, favoring a doctrine of alliance-based constructive confrontation with China over one reliant on tariffs on Chinese imports to create negotiating leverage to prevail upon China to remediate its unfair trade practices.[125] Nevertheless, the multiple rounds of tariffs the Trump administration has placed on Chinese imports coming into the United States generated over $50 billion in revenues to the U.S. Treasury between February 2018 and the end of 2019.[126] The Tax Foundation estimates tariff collections from duties on Chinese goods imports to the United States will ultimately reach $80 billion.[127] While this should be viewed as a unique, one-time, one-off windfall, the United States should take the opportunity to reinvest a considerable share of those sums toward financing a comprehensive U.S. innovation and competitiveness agenda, which would include funding for many of the proposals called for in this report to stimulate U.S. manufacturing innovation. ITIF suggests Congress work with the next administration to develop a comprehensive $2.5 billion U.S. innovation and competitiveness package funding many of the key proposals called for in this report. In this regard, it's important that further stimulus in response to the COVID-19 crisis should focus not just on short-term recovery, but also the long-term competitiveness of key technologically sophisticated, traded-sector industries of the U.S. economy, especially manufacturing.

CONCLUSION

A vibrant, innovative, high-value-added manufacturing sector is vital to the strength and competitiveness of the U.S. economy. But the health of U.S. manufacturing cannot be taken for granted, especially in the face of ever-more-intense international competition and the rapid pace of technological change. Public policy plays an important role in creating the environment in which U.S. manufacturing can flourish. The policy recommendations related to strategy/analysis, technology development and diffusion, finance, tax, and talent development recommended in this report can chart the way forward toward a revitalized U.S. manufacturing economy.

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