THE CENTURY FOUNDATION

REPORT HIGH WAGE AMERICA

A Strategy for Rebuilding the Manufacturing Sector in the United States

SEPTEMBER 20, 2017 — FRED BLOCK

Donald Trump's promise to bring back millions of manufacturing jobs was an important element in his surprising electoral victory. Trump was able to win enough blue-collar and normally Democratic voters in Pennsylvania, Michigan, and Wisconsin to cement his Electoral College majority. However, there are good reasons to doubt that Trump's policies will achieve what he has promised. Already, announcements from companies such as Carrier and Boeing indicate that big firms are continuing to move jobs overseas, despite Trump's promises that he would stop this trend in its tracks.[1]

Most importantly, Trump's first budget proposal threatens to cut many of the key programs that are vital for rebuilding U.S. manufacturing. Budgets for federal research and development spending that generate future technologies would be slashed.[2] In particular, Mick Mulvaney, Trump's budget director, has zeroed out the Manufacturing Extension Partnership that has provided services to small manufacturing firms for almost thirty years, and he also proposed the elimination of the Energy Department's promising ARPA-E program that has supported cutting-edge research. There is also a big cut to the Obama administration's most important manufacturing initiative—Manufacturing USA, the effort to create a national network of advanced manufacturing institutes. A think tank funded by high-tech firms puts it this way:

> *The administration's budget proposal would undermine America's long-term growth prospects by slashing investments that are critical to the country's innovative capacity and to the competitiveness of its most strategically important industries. Especially when it comes to areas ranging from scientific and engineering research to workforce education and skills, congressional leaders should declare the proposal "dead on arrival."*[3]

Trump's promise to revive the manufacturing sector in the United States could be realized, but doing so requires a strategy that is completely different from what we have seen so far from his administration. The strategy proposed in this report builds on lessons that have been learned from the past three decades of innovation policies. It is a strategy that requires a high level of coordination among policymakers in Washington, D.C., as well as with public-sector and private-sector actors at the state and local levels. It also requires increases in federal spending in some of the same programs that have been threatened with cuts. The outcome of this year's budget decisions could determine if advanced manufacturing policy moves in the right direction or takes a sharp detour at a critical moment in the sector's history.

Why It Is Important to Rebuild Manufacturing

The Century Foundation report, "Why Manufacturing Jobs Are Worth Saving,"[4] has presented a powerful case for the practicality and desirability of rebuilding the U.S. manufacturing sector. That report makes four basic points:

- Careful studies have shown that many products can be profitably produced in the U.S. by a well-paid workforce

because the production processes involved use sophisticated machinery that assures high levels of output for each hour of labor.

- While capital-intensive manufacturing typically takes place in workplaces that employ far fewer people than the factories of the 1950s, a vibrant manufacturing sector can be critical to the health of both urban and rural communities because of the unique linkages of manufacturing work.

- There is now a close connection between advanced manufacturing processes and the research and development efforts that feed into these processes, so that if the United States lacks manufacturing capacity for certain products, it will also ultimately lose the research and development capacity supporting those products as well. It follows that, for the United States to continue pioneering new industries, the nation needs a strong manufacturing sector.[5]

- Manufacturing jobs generally pay better than other jobs available to those without a college degree, and they are critical to the economic vitality of many states in the Midwest and Southeast.

The Special Challenges of Twenty-First-Century Manufacturing

There are two distinct ways in which twenty-first-century manufacturing differs radically from mid-twentieth century manufacturing. First, contemporary manufacturing is highly dependent on cutting-edge science and technology. Whether it is a question of using newly developed composite materials, relying on the latest advances in robotics, or incorporating other recently developed technologies, manufacturing now relies heavily on the research being done in government-funded laboratories. This is true of the latest models of smart phones, solar panels, robots, wind turbines, advanced batteries, and pharmaceuticals, but it is also increasingly true of airplanes, automobiles, machine tools, and even more mundane products such as textiles and building materials.

This pattern is particularly clear when one thinks of the seemingly humble light bulb. For more than a century, light bulbs with either carbon or tungsten filaments totally dominated the marketplace, and there was little change in a standard light bulb between 1950 and 2000. But in the twenty-first-century, the pace of change in lighting has accelerated rapidly, with a variety of new and more energy-efficient technologies replacing the incandescent bulb. The compact fluorescent lamp (CFL) was the leading technology in the early 2000s, but it has already been surpassed by light bulbs based on light emitting diodes (LED), which are longer-lasting, more energy-efficient, and continue to fall in price. Moreover, the flexibility of LED lighting is, in turn, changing the industry that produces lighting fixtures, since an infinite variety of configurations are now both feasible and affordable.

The second key change in manufacturing is that it is now a "team sport," in that manufacturing firms in and across sectors are much more mutually dependent. Back in the 1920s, for example, Henry Ford sought to excel in manufacturing as an individual sport. He built the River Rouge complex with its own electrical power plant, its own steel mill, and its own glassmaking facility, so that he could build cars without having to purchase any inputs from other firms. Today, however, that strategy would make no sense. Firms that specialize in making glass or steel or carburetors or transmissions or seating assemblies can supply those components more efficiently and at lower cost than can an automobile company. This is true because specialization allows a firm to make substantial investments in the technical knowledge and the skilled workers that are required to keep improving the specific product that it makes. The consequence is that today, as much as 70 percent to 80 percent of the value added of a typical automobile is purchased by the automobile manufacturer from suppliers.

Both research-intensive innovation and specialized, disaggregated manufacturing work in the same direction. In contemporary manufacturing, an individual firm is highly dependent not only on outside scientists and engineers, but also on other firms that are buyers or suppliers or collaborators in producing particular things. Even Elon Musk, CEO of Tesla and a person who aspires to the transformative role played by Henry Ford, relies on partnerships with other firms. The huge battery factory that he is building in Nevada, for example, is a joint undertaking with Panasonic, the Japanese electronics firm. Even the most ordinary manufacturing entrepreneurs must line up multiple partners before they can undertake any major new projects.

This dependence on others can create a serious problem, however. A firm, whether big or small, might have a great idea about a new product, but it cannot move forward until it finds the appropriate partners for both developing and making the product. Finding appropriate partners, in turn, is difficult and time-consuming, and some potential partners might exaggerate their skills, or otherwise prove to be unreliable or untrustworthy. And even when one has found good partners, uncertainty remains.[6] With advanced manufacturing, figuring out how to mass-produce a complex product is often a major challenge, and it can be difficult to find a labor force with the skills needed for production. Even if these hurdles can be overcome, there is still the considerable risk that the new product will not find a market, either because it is rejected by regulators or by consumers.

Foreign governments have responded to the challenges of twenty-first-century manufacturing by creating specialized programs that are designed to help firms solve such problems. Many of these programs are consciously based on the model of agricultural extension services that were pioneered in the United States in the early twentieth century, through which land-grant colleges employed extension agents who supported farmers with practical expertise and scientific knowledge in order to maximize the nation's agricultural output.armers producing the same crops but in different locations faced differing, and very specific, challenges of soil quality, irrigation, and specific pests, so agricultural

extension was organized on a highly decentralized basis, but extension agents also got assistance from large agricultural laboratories that could organize research on problems that were particularly intractable. In a similar fashion, the best manufacturing extension programs are highly adaptable and decentralized, but they are also able to connect firms to cutting-edge technological resources that might exist on the other side of the country.

Germany's Fraunhofer Society and Japan's Kohsetsushi centers, for example, both provide a number of distinct services that can make a huge difference in helping firms meet the challenge of twenty-first century manufacturing.[7] First, they help firms find the highly skilled partners they need for both research and production. Second, they assist firms and their subcontractors with the difficult task of scaling up to mass production. Third, they help coordinate with local educational institutions to create new programs that help prospective employees gain the skills that they need for new production processes. Fourth, they help multiple firms in an emergent industry develop roadmaps that illuminate the specific challenges of developing a market for new products and provide strategic advice as to how to manage those challenges.

The German and Japanese programs have roughly 22,000 and 6,000 employees, respectively, while the U.S. program—the Manufacturing Extension Partnership (MEP)—is funded with about $130 million federal dollars and has a staff of only about 1,300 employees.[8] With at least one located in each of the fifty states as well as in Puerto Rico, MEP centers often develop as partnerships between the federal government, public and nonprofit institutions such as universities and research labs, and private entities. These partnerships can build a critical mass of technical experts that can assist manufacturers in product development, supply chain integration, and innovation. The U.S. program is targeted at small firms—focusing mostly on just the second task, which is to master the technologies of advanced manufacturing, such as quality control and use of sophisticated machine tools. The federal dollars support regional centers in every state, which also depend on state-government and client fees. But while MEP is small, it is effective. One study found that every dollar invested in MEP generates an estimated $32 in in economic growth, which translated into $3.6 billion in new sales for the small- and medium-sized enterprises (SMEs) targeted.[9] Through 2011, the MEP program had engaged with over 400,000 SMEs, evidence of the great demand for MEP services.[10]

VIDEO: WHAT IS MEP?

What is MEP?

In focusing on advanced manufacturing innovation within small- to medium-sized firms, as noted above, MEP centers enhance productivity and product development, helping firms to grow and expand, and creating jobs in the process. An emphasis on innovation is key to the success of these centers.

One specific example of MEP at work is a center in Idaho called Techhelp. A partnership of Boise State, Idaho State University and the University of Idaho, Techhelp works with small- and medium-size manufacturers to get them off the ground and connect them to global supply chains. Techhelp assisted Rekluse, a small manufacturer making clutches for off-road motorcycles, go from an idea developed in a garage to a full-fledged company with an innovative prototype ready for production and sale. Indeed, with the assistance of Techhelp, Al Youngwerth, the founder of Rekluse, was able to make his idea into a working prototype in less than six months. Techhelp brought in mechanical engineering students from Boise State to develop the prototype; one of those engineering graduates is now the president of the company.[11] The center also provided the funding necessary for the company to grow and thrive. Now, Rekluse produces clutches that are considered to be some of the most innovative and durable automatic clutches in dirtbiking,[12] and they employ and train workers in robotics and the operation of computerized machine tools.

MEP's modest size and funding notwithstanding, a W. E. Upjohn Institute analysis finds it has several economic benefits on the national level.[13] According to Upjohn's most conservative modelling, MEP adds 142,381 jobs that would not be created or retained without MEP activities, and that the centers' activities increase GDP by $15.4 billion, output by $29.9 billion, personal income by $8.4 billion, and personal income tax revenue by $1.1 billion, well above the tax dollars needed for funding the program. Clients surveyed also reported increased sales and savings based on MEP assistance.

It seems obvious that the United States needs a much larger and more ambitious program of manufacturing extension if the nation is to succeed in twenty-first century manufacturing.[14]

A Promising Experiment

Under President Obama, the United States launched a little-known experiment in a new form of manufacturing extension that holds considerable promise—the creation of a network of advanced manufacturing institutes, under the collective name of Manufacturing USA.[15] This effort was deliberately built on a successful model of U.S. innovation policy that was started in the 1980s. The model was pioneered by the National Science Foundation (NSF) with the creation of Industry-University Cooperative Research Centers[16] and Engineering Research Centers.[17] These centers are built on university campuses to develop a specific technology that would be useful for industry. The NSF provides five years of funding to a scientist or engineer who is able to assemble a strong interdisciplinary team. He or she needs to recruit industry partners, who pay dues to support the center and send their researchers to work side-by-side with the university researchers. This model has proven very successful in creating effective collaborations and in developing a continuous stream of important new technologies. As a consequence, the model has been adopted by other government agencies and there are now many of these centers organized at universities and federal laboratories.

The Obama administration built on this model when they started an initiative in 2012 to create a series of advanced manufacturing institutes, which were expanded further under the bipartisan Revitalize American Manufacturing and Innovation Act of 2014 (RAMI). The RAMI Act lays out the ambitious purposes of the institutes:

- improve the country's manufacturing competitiveness and increase production of goods manufactured predominantly within the United States;
- stimulate U.S. leadership in advanced manufacturing research, innovation, and technology;
- facilitate transition of innovative technologies into scalable, cost-effective, and high-performing manufacturing capabilities;
- facilitate access by manufacturing enterprises to capital-intensive infrastructure;
- accelerate development of an advanced manufacturing workforce;
- facilitate peer exchange of and documentation of best practices in addressing advanced manufacturing challenges;

- leverage nonfederal sources of support to promote a stable and sustainable business model without the need for long-term federal funding; and

- create and preserve jobs.[18]

Manufacturing USA represents a best-practice model for industrial policy—one that does not pick individual winners and losers in the economy but rather invests in the sub-sectors which show the most promise for maintaining American manufacturing leadership and protecting national security interests. The partnerships amongst business, education and government has allowed German manufacturers to focus their manufacturing sector on technically advanced manufacturing, thereby maintaining Germany's competitive edge even in the face of competition from China and other emerging nations.[19] Like the NSF centers, the Manufacturing USA institutes are designed to bring together researchers from universities and federal laboratories with scientists and engineers from firms to work on the challenges of different advanced manufacturing technologies (also known as additive manufacturing, or AM), such as robotics or 3D printing (also known as additive manufacturing, or AM). The designers also saw these institutes as bridging organizations whose members would include businessfirms, both large and small; universities; and federal laboratories. This approach was based on the recognition that similar kinds of bridging organizations had played a key role in helping develop technological clusters, such as the biotechnology industry in San Diego.[20] Bridging organizations can help firms find the partners they need.

There are fourteen Manufacturing USA institutes in all, although six of them are still very new. Each institute focuses on a particular advanced manufacturing technology, such as 3D printing, flexible electronics, or producing polymer composite materials. The full list of the institutes displayed in Table 1 illustrates how they seek to help manufacturers leap from twentieth-century manufacturing strengths into twenty-first-century leadership. For example,Detroit-based Lightweight Innovations for Tomorrow (LIFT) will help automakers (and other fabricators) create fuel-efficient lightweightmetals, and AIM Photonics will build on upstate New York's historic strength in imaging (pioneered by Kodak and Xerox) to create a nub for integrated photonic circuit manufacturing.

Table 1. The Fourteen Initial Manufacturing USA Institutes			
Name	**Technology**	**City**	**Year**
National Additive Manufacturing Innovation Institute (America Makes)	Additive manufacturing (3D printing)	Youngstown, Ohio	2012
Digital Manufacturing and Design Innovation Institute (DMDII)	Digital design and manufacturing	Chicago, IL	2014
Lightweight Innovations for Tomorrow (LIFT)	Lightweight metals	Detroit, MI	2014
American Institute for Manufacturing Integrated Photonics (AIM Photonics)	Integrated photonic circuits	Albany, NY	2015
America's Flexible Hybrid Electronics Manufacturing Institute (NextFlex)	Flexible electronics	San Jose, CA	2015
Advanced Functional Fabrics of America (AFFOA)	Novel fibers and textiles	Cambridge, MA	2016
Advanced Tissue Biofabrication Manufacturing Innovation Institute (ATB-MII)	Human tissue and tissue-related products	Manchester, NH	2016
The Next Generation Power Electronics Manufacturing Innovation Institute (PowerAmerica)	Wide bandgap semiconductors	Raleigh, NC	2014
Institute for Advanced Composites Manufacturing Innovation (IACMI)	Advanced polymer composites and recycling	Knoxville, TN	2015
Clean Energy Smart Manufacturing Innovation Institute (CESMII)	Smart sensors and digital process controls	Los Angeles, CA	2016
National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL)	Biopharmaceuticals	Newark, DE	2016
Advanced Robotic Manufacturing	Collaborative robotic technologies	Pittsburgh, PA	2017
Rapid Advancement in Process Intensification Deployment (RAPID)	Energy efficiency of manufacturing processes in industries such as oil, paper, and chemical	New York, NY	2017
Reducing Embodied Energy and Decreasing Emissions (REMADE)	Reuse, recycling, and remanufacturing of materials	Rochester, NY	2017
Source: Government Accountability Office; Department of Defense; Department of Energy.			

The institutes are funded with a combination of federal dollars and funds from state and local governments and from industry. The Obama administration spent around $225 million per year on this program in fiscal years 2016 and 2017, although its budget request for 2017 asked for $2 billion over ten years to expand the network to forty-five advanced manufacturing institutes.[21] Most of the institutes have different categories of membership, with large founding firms committing as much as $1 million over five years, while other firms can join for as little as $15,000 per year.[22]

The process for creating these institutes has been competitive, with the most successful applicants having already begun creating a bridging organization that links together public sector agencies, universities, federal laboratories, and business firms involved in developing a promising advanced technology in a particular geographical area. Once the institute is funded, it becomes the bridging organization that then takes on the tasks of developing a strategy for the emergent industry.

To be sure, the main activity of these institutes is to provide funding for research projects initiated by member organizations that are designed to overcome specific barriers to the cost-effective development of these technologies. The institutes use a granting program to disburse funds to what are judged to be high-priority projects, and there is generally an emphasis on cost-sharing, with universities and federal laboratories donating research facilities and businesses providing some portion of the cost of a given project. These highly focused projects are seen as the main channel for moving these advanced technologies forward.

However, the structure of the institutes allows them to do much more than simply fund the advancement of a specific type of technology. First, as suggested, the institutes are a “collaborative public space” in which firms can quickly find the qualified partners that they need for research projects or for moving forward to actual production tasks.[23] Moreover, the staff of the institutes can play a key role in this matchmaking exercise by making the appropriate introductions that help participants find the partners they need. Sometimes this matchmaking involves drawing on national or even international networks of expertise. The assistance can be particularly critical for startup firms that have limited resources and limited knowledge of the business terrain. Second, the institutes are well-positioned to organize road-mapping exercises in which participants pool their knowledge to locate key milestones and barriers in bringing these technologies up to scale. The process can also identify regulatory barriers that have to be negotiated and the institute can play a constructive role in working with regulators to address potential issues. Third, most of the institutes have taken an active role in workforce development, including collaborating with local community colleges to develop appropriate

curricula for production workers with the needed skills. In some cases, they have also been working with engineering programs to help train production engineers with a deep understanding of the particular technology that is being developed.

While these institutes are intended to draw on expertise that is geographically distant from its actual physical location, the idea is that a concentration of people and face-to-face relations in a particular place will accelerate both the sharing and advancement of knowledge. In this way, the conceptualization of these institutes draws on social science studies of industrial districts that emphasize the advantages of having a large number of firms operating in close physical proximity in the development of new technological specialties. So the hope is that each of these institutes would become the center of an industrial cluster dedicated to this particular technology. To be sure, the use of 3D printing or of new polymer composites, to take well-known examples, would be expected to diffuse across the entire economy, but the industrial cluster around the institute would remain the dynamic center of new developments around this particular technology.

The first of these Manufacturing USA institutes was launched in 2012, and most of them have only been in existence for a year or two, so it is far too early to tell with certainty whether they will produce dynamic new industrial clusters. However, we do know that their existence has been eagerly welcomed by industry participants. As of late 2016, the first eight institutes had 753 partners, most of which are business firms, and these memberships involve some financial commitment by the firms. A Deloitte evaluation found that the membership already reaches 15 percent of U.S.-based global manufacturing leaders, and that these members have made 9,424 connections through Manufacturing USA.[24] Examples of these connections and early successes include:

- a new end-to-end carbon fiber production line that allows companies, especially small and medium enterprises to test new technologies;

- a strategic collaboration between the West Coast–based technology industry and the Midwest-based printing industry to tap into the latter's experience printing on flexible products;

- an industry-wide analysis that identified a shortage of 200,000 workers in lightweight manufacturing, and the creation of a work-study program with an Ohio community college to start filling that gap; and

- In 2015, the Institute for Advanced Composite Manufacturing Innovation worked in close collaboration with Oak Ridge National Laboratory to use 3D printing and new composite materials to produce an electric-powered replica of a Shelby Cobra sports car; the whole design and manufacturing process took only six weeks, demonstrating the value of these technologies for prototyping new products.

In the initial design, these institutes are supposed to be completely self-supporting after five years, but it seems obvious that this is not a realistic goal.[25] The process of transforming a new production technology into a viable industry takes much longer than five years, so it is likely that many of these institutes will need additional federal funding for them to keep going and reach their full potential. State and local governments often lack the resources to fill in with major funding, and without strong government partners, it is often difficult for the other participants to maintain their cooperation. In short, we will soon face a decision point in which we must decide to learn from and expand this experiment, or see it peter out. In fact, the Trump budget accelerates the process of decline by proposing an immediate defunding of five of the institutes.

Heeding the Lesson of Manufacturing Extension

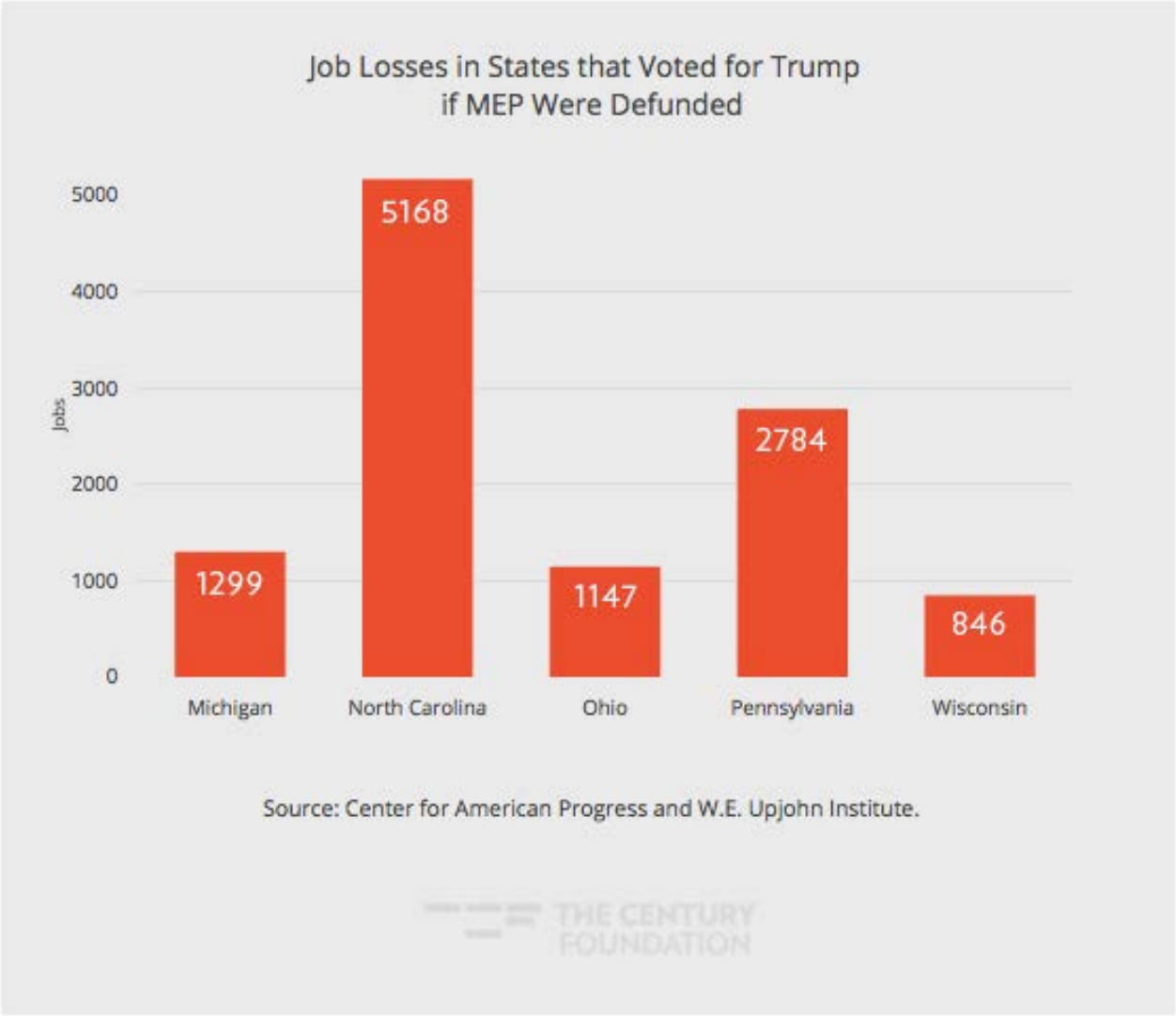
The fundamental lesson from the past thirty years of manufacturing policy is that a revival of U.S. manufacturing requires substantial budgetary commitments from the federal government. However, in recent years, federal research and development spending has been falling sharply as a share of GDP, and this means that federal laboratories and researchers based in universities have been fighting over a declining share of resources.[26] Since federal programs to support commercialization of new technologies and to support advanced manufacturing are dependent on continuing scientific and technological advances, it makes no sense whatsoever to fund the former while restricting the funds for the latter. Moreover, the proposed budget of the Trump administration goes in the wrong direction because it cuts basic research funding by $4.3 billion[27] and it zeroes out a number of key initiatives for commercialization and advanced manufacturing.

President Trump's budget from the spring proposes eliminating the funding for the Manufacturing Extension Partnership, which currently receive half of its funding from the federal government. According to the Center for American Progress, many of these job losses would fall hardest on states that voted for Trump in the November 2016 election (see Figure 1).

Other programs at risk include the Economic Development Administration, which is tasked with helping regions recover from a loss of manufacturing employment. Completely eliminating this agency would undermine economic development in places where it is needed most, particularly in the Heartland.[28]

The United States needs to act soon to reverse the steady decline of federal research and development spending as a percentage of GDP. Instead of making cuts, the nation instead should be ramping up to spend something on the order of

FIGURE 1


Job Losses in States that Voted for Trump
if MEP Were Defunded
5000
4000
3000
2000
1000
0
Jobs
1299
5168
1147
2784
846
Michigan
North Carolina
Ohio
Pennsylvania
Wisconsin
Source: Center for American Progress and W.E. Upjohn Institute.
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an additional $3 billion per year for support of manufacturing extension and maintaining and expanding the network of advanced manufacturing institutes. An effort on that scale is commensurate with the efforts of the major U.S. economic competitors, and past experience suggests that such an investment will quickly pay for itself through greater economic dynamism, more high-quality jobs, and increased tax revenues.

Out of this ramped-up support, $1 billion of those new dollars would be used to increase the Manufacturing Extension Partnership by a factor of six, so it would ultimately have a staff of 8,000 employees spread across fifty states. Another $1 billion per year would make it possible to fully support forty-five advanced manufacturing institutes and eliminate the threat that successful institutes would be defunded after only five years. The requirement for matching funds from industry and other sources would continue and there would be ongoing evaluation so that those institutes that were not meeting performance standards would be defunded while new ones would be created.[29] The final $1 billion would be spread across existing manufacturing-related programs in different federal agencies, such as Department of Energy programs to support clean energy innovation and NSF's Engineering Research Centers, so as to increase their scale and effectiveness.

However, there are three other significant policy changes that are absolutely necessary to assure the success of this kind of manufacturing effort: ending the winner-take-all model, coordinating advanced manufacturing with infrastructure spending, and creating new financing mechanisms for small- and medium-sized enterprises. Without significant progress on these three fronts, there is a good chance that the effort to rebuild U.S. manufacturing will fail.

Ending the Winner-Take-All Model

In recent decades, U.S. economic growth has been based on a winner–take-all economic model, in which the gains from significant technological advances go disproportionately to a handful of successful "winners" rather than being shared more broadly across the employees of the company, the industry, or the nation.[30] However, Germany, our most important rival in advanced manufacturing, has a very different model. German manufacturing workers are paid better and have better employee benefits than comparable U.S. workers.[31] Just as importantly, these German workers have a real and influential voice in the companies that they work for, through labor unions, through work councils, and in some cases, through participation in the firm's management boards.[32]

In the winner-take-all model, production workers are viewed as easily replaced low-skill employees who need to be carefully monitored to maintain the requisite work effort. This employment strategy simply won't suffice in the technologically sophisticated context of advanced manufacturing, where employees have a significant level of skill and management is dependent on their judgment to manage and supervise the production process to get the best possible

results. Such employees cannot be treated as throwaway people; they need to be recognized as a vital and important part of the enterprise. Rebuilding the U.S. manufacturing sector requires replacing the winner-take-all model with a strong commitment to shared and inclusive prosperity.

Coordinating Advanced Manufacturing with Infrastructure Spending

For years now, public spending on infrastructure in the United States has also been falling as a share of GDP.[33] This decline has left the United States more vulnerable to the catastrophic collapse of bridges and the slow and relentless failure of mass transit systems that have experienced decades of deferred maintenance.[34] Moreover, the infrastructure crisis is particularly serious in the face of global climate change. The devastating impact of Hurricane Katrina and Superstorm Sandy are just harbingers of the apocalyptic disasters that could occur if we fail to increase spending to improve the resilience of areas with dense populations. At the same time, infrastructure spending is also central to efforts to reduce dependence on carbon-based fuels.

But the infrastructure crisis is also an opportunity. A dramatic increase in infrastructure spending is a necessary ingredient in the revival of U.S. manufacturing. With appropriate coordination, rebuilding bridges, constructing more windmills, and modernizing mass transit systems can give a huge boost to both existing and new manufacturing firms. Moreover, building smarter infrastructure such as the next generation electrical grid will create demand for entirely new products that can generate more manufacturing jobs.

Creating New Financing Mechanisms for Small- and Medium-Sized Enterprises

The United States has long had a serious problem in providing adequate funding for small- and medium-sized enterprises, especially those trying to push innovative technologies.[35] The problem is particularly acute because there is not as strong a tradition in the United States of bank lending to manufacturing firms as there is in much of Europe. The venture capital system has worked fairly well for firms developing computer software and biotechnologies, but its track record outside of those domains is weak. There was a brief boom, for example, in venture capital funding for firms pursuing various clean energy technologies, but it ended quickly, leaving many young firms to file for bankruptcy.

One proposed response to this problem has been to substitute space for capital by locating startup firms in “innovation orchards” where they would have easy access to the expertise, equipment, and other resources that they need to flourish.[36] This is a more ambitious version of the incubators that a number of localities have set up to support startup

firms. While creating low-cost and strongly networked environments can play an important role in helping young firms to survive, these are not substitutes for developing a new financing model. There are several possible models that could address this problem.

- The creation of a network of *public* venture capital entities that draw heavily on the expertise of the federal laboratory system. In-Q-Tel, the CIA's venture capital arm, has proven that public venture capital efforts can be successful.[37] Scaling up these initiatives could provide a critical avenue of support for promising startups.

- The federal government could follow a model that Germany has used that relies on loan guarantees to support financing for community banks and credit unions.[38] A program like this would have to be phased in gradually, so that the lending institutions could work with consultancies to develop the expertise needed to differentiate among more-promising and less-promising firms.

- Through a public-private partnership, the federal government could create a new stock market for startup firms that would involve careful vetting of the firms that sought to be listed. Newly created mutual funds could buy shares from a diversified portfolio of these firms that would in turn be purchased by investors. On the same theory as venture capital, even if only two firms out of twenty proved successful, the returns would be positive. (In addition to providing access to capital, this new stock market would also share the gains from technological advancement more broadly, attenuating the winner-take-all nature of today's economic environment.)

The manufacturing sector needs reforms like these that would greatly increase the access of startup firms to capital—otherwise, the revival of manufacturing in the United States is unlikely to happen.

Taxation, Trade, and Education

The current administration's focus on cutting business taxes and negotiating better trade deals will not, by themselves, lead to a revival of U.S. manufacturing. However, there are critical changes in tax and trade policy that would help to support the rebuilding of U.S. manufacturing capacity. The central problem is that multiple generations of business executives have been taught that manufacturing should always be outsourced to low-wage locations overseas, and U.S. tax and trade policies have reinforced this bias.

Specifically, profits earned by U.S. subsidiaries overseas are not taxed until those profits are brought back to the United States. This has of course created a powerful incentive for firms to shift production offshore, and the strength of this incentive is indicated by the accumulation of large overseas cash hordes by U.S.-based firms. Simply changing to a tax

regime in which profits were taxable in the U.S. whether or not they were repatriated would be an important step in shifting the incentives for corporate managers.[39] Another step would be to create a tighter set of global rules that prevent firms from arbitrarily parking their profits in low-tax locations in an effort to lower their overall tax rate.

Similarly, U.S. trade negotiators for the past three decades have not prioritized creating a level playing field for U.S. exports. Their focus instead has been on two other goals that have protected certain industries but left manufacturing exposed. First, they have pushed other nations to enforce intellectual property rights that protect the profits of U.S. businesses that produce pharmaceuticals, software, and entertainment products. For example, because of patent protection, the cost of a three-month supply of a drug for Hepatitis C in the United States is $84,000, while an Indian firm produces a generic version that sells for $900.[40] U.S. trade negotiators have pushed hard to block India from selling its cheaper version to other countries. But when other nations have to spend millions to import expensive patent-protected medicines—often produced by U.S. companies in overseas plants—they have less money to spend on purchasing U.S.-made goods.[41]

Another priority for U.S. trade negotiators has been to pressure other nations to broaden market access for investment by U.S. firms that provide financial services, such as banking and insurance, and to enact investor protections for U.S. transnational firms. While this benefits U.S. financial companies, it does nothing to encourage U.S. exports, and encourages the offshoring of production. There is an urgent need to reduce this emphasis on intellectual property and investor protection and shift the priorities of U.S. trade policy back to reducing barriers to the export of U.S. manufactured goods. Such a shift would send an important signal to managers that producing in the United States makes sense even when a significant share of output is destined for export.

Finally, the manufacturing strategy proposed here depends upon the United States reversing the educational funding patterns that have been in place since the 1970s. Through most of the nineteenth and twentieth centuries, the United States led the world in investing in a highly educated population, but since the 1970s, public investments in education have stagnated, and many other nations have surpassed the United States in both the percentage of young people going to college and the knowledge base of the average high school graduate.[42] In recent years, financial barriers block many young people in low-income households from going to college, and a significant proportion of those who do graduate carry a heavy burden of debt from student loans.

Inadequate levels of educational attainment threaten the future of manufacturing in two ways. First, the United States has been overly reliant on importing foreign scientists and engineers to do the cutting-edge research required for significant technological advances. There is an obvious need to draw more young people who grow up in the United States into these scientific fields.[43] Second, many of the production jobs in advanced manufacturing require employees to

develop technical skills, perhaps also through more robust apprenticeship programs, that are well beyond those of typical high school graduates. Without raising the numeracy and literacy of job seekers, the United States could face serious skill mismatches that would slow the spread of advanced manufacturing.

Conclusion

There are powerful reasons to prioritize the rebuilding of U.S. manufacturing capacity, but mapping an effective set of policies to accomplish this goal requires understanding that twenty-first-century manufacturing is very different from that of the mid-twentieth-century. Established policies in which state governments offer reduced taxation and other inducements to big corporations to open a factory are no longer effective in this new environment. Rebuilding U.S. manufacturing requires new priorities for the federal government and complementary initiatives at the state and local level.

At the federal level, we have identified four primary policy priorities and three secondary policy priorities that are necessary to facilitate a revival of manufacturing in the United States.

Primary Federal Policy Priorities

1. Changes in government tax and spending policy to shift away from the winner-take-all model of economic growth.

2. Significant increases in federal research and development expenditures, including another $3 billion per year for advanced manufacturing and manufacturing extension.

3. Increased public investment in infrastructure that is coordinated with manufacturing initiatives to build domestic manufacturing capacity.

4. New financing mechanisms that provide support for small- and medium-sized manufacturing firms.

Secondary Federal Policy Priorities

1. Eliminate the provision in tax law that allows U.S. foreign subsidiaries to indefinitely delay paying taxes on overseas profits.

2. Shift the priorities of trade policy away from intellectual property and investor protection and back toward

expanding foreign markets for U.S. exports.

3. Increase the society's investment in public education, from preschool to graduate training.

The Trump administration, unfortunately, has not embraced any of these goals, and in fact their budget priorities move in precisely the wrong direction. But even if the Congress were to reject the president's budget priorities, the obstacles to advanced manufacturing cannot be overcome by the federal government alone. Progress requires initiatives by public and private actors at the state and local level as well. And favorable federal policies would make it far easier for political actors at the local and the state level to build effective political coalitions to support manufacturing activity.

As has been shown by the creation of advanced manufacturing institutes, the path toward effective coalitions requires building bridging organizations that bring government, universities, businesses and other constituencies together to develop policies and institutions to create manufacturing clusters. This involves creating collaborative public spaces where critical research can be done, establishing manufacturing extension programs that provide firms with help in scaling up production, and workforce development programs that provide potential employees with the skills required for these new jobs.

Efforts at the state and local level will not work, however, if initiatives to boost manufacturing turn into yet another winner-take-all effort where corporate leaders get very rich and employees work for low wages with little employment security. Advanced manufacturing can be a key element of a stronger and fairer economy, but such programs must be guided from the outset by a solid commitment to the goal of widely shared prosperity.

This report was published by the Bernard L. Schwartz Rediscovering Government Initiative, founded in 2011 with one broad mission: countering the anti-government ideology that has grown to dominate political discourse in the past three decades.

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