SSN SCHOLARS STRATEGY NETWORK
STRATEGY BRIEF

A STRATEGY TO FOSTER ADVANCED MANUFACTURING NETWORKS IN THE UNITED STATES

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Many voices are calling for the United States to rebuild its manufacturing strength – pointing to advanced technologies that American entrepreneurs and workers could develop to fashion needed products in highly automated factories. Innovative efforts dot the country in sectors such as clean energy technologies, robotics, and advanced battery production. But in a fast-moving, competitive world, America needs to speed the pace and increase the scope of promising new undertakings in order to keep up with other nations in further rounds of innovation.

What can government do? Are there precise, effective steps the U.S. federal government can take to help rebuild and update the nation's manufacturing capacities? President Barack Obama's administration has taken some constructive steps. However, many in the administration are wedded to old-fashioned blueprints that presume government can do little more than fix market failures, fill gaps left by reluctant private investors, or jump-start new ventures and simply hand them off to businesses left to proceed on their own. This seriously underestimates what can be done by government in ongoing partnership with entrepreneurs, engineers, and scientists.

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A better and bolder way forward takes off from the spreading recognition that marketable technological advances now depend on networks among firms and require strong links between manufacturers and researchers. Government can provide ongoing help to build such ties and thus spur ongoing innovative efforts to discover, manufacture, and market cutting-edge products. In this strategy brief, we make the case for using government resources to foster innovative networks – and lay out the specific next steps in public policy that could make the United States a world leader in advanced manufacturing for decades to come.

Why Bother with Manufacturing?

It is not obvious that the United States should try to reinvent manufacturing. Decades ago, America was a manufacturing giant, to be sure. But shuttered steel plants, crumbling textile towns, and abandoned shoe factories now litter the land; and it has been a struggle to preserve the U.S.-owned automobile industry. Maybe the time for domestic manufacturing has come and gone, and Americans should focus instead on health care provision, computer software development, and financial operations – plus the provision of local personal and hospitality services that are not readily outsourced to distant countries.

There is something to these arguments. It would be futile to push against the tides of history and try to compete with foreign countries such as China, Vietnam, and Bangladesh to recreate low-wage, mass production industries whose time on our shores is past.

But there are several good reasons to consider a strategy to encourage new advanced manufacturing development in key areas. Clean energy is one promising area, including solar and wind power and the production and deployment of advanced batteries. Additional frontiers include robotics and the production of new composite materials that draw on nanotechnology. Flourishing ventures in these areas could become a vibrant part of the U.S. national economy and help to revitalize many regional economies as well.

- **New manufacturing businesses create jobs that pay decent wages** – and workers who spend those wages allow other businesses to flourish in surrounding communities. In today's cutting-edge industries, when manufacturing firms are located in the same place as companies or agencies doing research and development, there can be fruitful back and forth between researchers and production engineers. But when big firms move either their manufacturing or their research overseas, as many are now doing, the United States loses both production and R&D jobs. We need to bring both research and development and manufacturing capacities back to America.

- **Advanced manufacturing improves the U.S. trade balance.** The U.S. trade deficit currently stands at about four percent of gross domestic product – dangerously close to the five percent level considered "cautionary" by economists. The growing trade deficit is in large part driven by growing imbalance between exports and imports of manufactured goods like computers, cars, and cell phones. Our merchandise trade deficit with China alone has undergone a threefold increase in little more than a decade, and is fast approaching $300 billion a year. Because imports of manufactured goods are responsible for approximately two-thirds of all U.S. imports and exports, our nation's efforts to recreate competitive manufacturing will necessarily play a key part in determining whether America's balance of trade improves or deteriorates further in future decades.

- **National security will benefit from new manufacturing skills and capacities at home.** Just as access to critical raw materials (such as petroleum or rare earth elements) has become a focus of geopolitics, reliable access to computer chips and other sophisticated manufactured products will become an increasingly important aspect of inter-state rivalries on the world stage. Even if major wars do not break out, it is easy to imagine international scenarios in which governments try to control trade in advanced products to exert leverage on other nations. We don't want the United States to become entirely dependent on importing advanced technologies from, say, China.

Promising Starts and False Premises

Even if there are good reasons to encourage advanced manufacturing, how will it happen? Government almost certainly has a role to play – but doing what?

The Obama Administration has pursued a series of initiatives that are designed to strengthen U.S. manufacturing capacity.

- Starting right after Obama moved into the White House, his administration oversaw the successful rescue and reorganization of General Motors and Chrysler. This not only ensured

the continued viability of those companies, but also saved hundreds of thousands of jobs at automotive suppliers across the country.

- The administration committed funds in the American Recovery and Reinvestment Act – the "Stimulus" – to jumpstarting the development of manufacturing capacities to produce clean energy products ranging from advanced batteries to electric cars and technologically superior solar panels.

- Following the advice of the President's Council of Advisors on Science and Technology, the Obama administration has launched an Advanced Manufacturing Partnership designed to link government, universities, and the private sector together in efforts to foster new manufacturing capacities.

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But there are important limits to the Obama administration's efforts to date. The automobile industry bailouts and stimulus appropriations were one-time outlays. Government funds are not being allocated on the scale needed to sustain new domestic manufacturing efforts. True, the Obama administration is now calling for the Advanced Manufacturing Partnership, but the proposed funding is far from sufficient.

Money is not the only issue. Obama administration officials are not yet thinking creatively enough about government's role in fostering advanced manufacturing, because they are wedded to an outmoded viewpoint about what government can usefully do. The Advanced Manufacturing Partnership is justified by arguments about "overcoming market failures" – that is, having government step in only where private actors are reluctant to get started or lack capacities to carry on. This way of thinking is excessively timid and misses the positive and sustained ways in which nimble and well-designed government efforts can spur economic innovation.

From Fixing Market Failures to Fostering Networks

Government works best when it does more than just patch things up. It can more effectively foster economic innovation – in this case, advanced manufacturing – by encouraging and supporting new ties among thousands of creative and entrepreneurial actors. Government can facilitate links among companies and build bridges between companies and researchers.

Recognizing the most proactive possibilities requires moving beyond inherited ideas. From Adam Smith onward, economists have recognized that there are certain things markets alone cannot provide. For example, it is very hard for private entrepreneurs to make a profit by providing clean air, tree-lined urban parks, or schools that teach even the poorest children. Such "market failures" have long been accepted as a justification for government to provide important public services.

In addition, the modern U.S. federal government has recognized that, if left to its own devices, the market would support less scientific research than society needs to continue making big productivity advances. That is why Congress created funding agencies – like the National Science Foundation and the National Institutes of Health – to cover much of the cost of basic research. For the same reason, the government invested in the Human Genome Project, a huge research undertaking that has already generated new products and new businesses.

Perhaps understandably, Obama administration officials are relying on such longstanding models to propose programs to revitalize U.S. manufacturing. But market failure notions limit the range of possibilities policymakers should entertain. The trouble with inherited market failure conceptions is that they imply a clear and fixed dividing line between the public and private sector. Government and private businesses are each supposed to stay on their own side of a fixed boundary and perform tasks that are clearly demarcated and separate. Hand-off metaphors are often used to make the point: government does some initial work or performs a useful task on the side, and then hands off the results to the private sector to make economic hay on its own.

But this isn't how many effective government policies to support economic innovation actually work. In many cases, there is no clear dividing line between government and private efforts; and one-time hand-offs almost never occur. Rather, innovations flow from ongoing partnerships in which government and private firms – and sometimes nonprofits, too – work together to overcome technological barriers in a sustained, back and forth, fully collaborative process. The idea that the government should just fix market failures assumes that those networks somehow just "happen." But that isn't really so. In fact, there is lots of evidence that governments can and should focus their energies both on establishing such ongoing partnerships and on making them work optimally.

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Throughout economic history, but especially in today's fast-moving global economy, many effective industries work on a network basis, relying on repeated collaborations among multiple firms of various sizes to invent, produce, and sell products. The days when Henry Ford could build a giant plant to make everything needed for an automobile under one roof are mostly long gone. Firms need to be nimble networkers. But particular firms, no matter how imaginatively run or initially well-financed, often have difficulty finding partners who are trustworthy, competent, and able to offer critical new skills and capacities. And networks do not function well when firms are unable to find the partners they need, or when those partners prove to be untrustworthy or incompetent.

We are not claiming that networked production is or should be universal, even today. Some items are still efficiently produced by single firms acting largely on their own. But in innovative advanced manufacturing – as in many sectors of agriculture, health care, and other industries where uncertainty is high – producers find it hard to translate their ideas into products by their own efforts alone. They need to be part of vibrant networks, and promising ventures can be undone if such networks are not available or fall apart. Here is where positive government action can make a difference. Various government agencies and actors have proven track records of coming in and helping firms and sister organizations overcome network dysfunction. Government efforts can foster the innovative network connections firms so badly need to succeed.

A Telling Success Story from America's Past

The U.S. federal government was in fact a global pioneer in fostering innovative production networks – to help millions of American farmers achieve the advances in productivity that fueled national economic growth from the Civil War into the twentieth century.

The Smith-Lever Act of 1914

"An Act to provide for cooperative agricultural extension between the agricultural colleges of the several states… and the United States Department of Agriculture…. giving of instruction and practical demonstrations of existing or improved practices or technology… to persons not attending…colleges in the several communities…."

Farming is a sector fraught with unpredictability. Amidst inevitable uncertainties about weather, insects, plant diseases, and other threats to harvest, farmers must, each year, make difficult decisions about which crops to plant and which seeds, pesticides, and fertilizers to use. To make good decisions, farmers are critically dependent on getting good information. They often turn to agricultural suppliers and the merchants who will purchase their crops. But are these reliable sources? Not necessarily, and commercial sources may not spread information evenly to all producers.

Starting in the 19th century, the U.S. federal government stepped in to help farmers gain access to state of the art knowledge:

- Subsidized by the Morrill Act of 1862, land grant colleges sprung up in dozens of states and included research and instruction in "useful arts" relevant to agriculture.

- Under the auspices of the U.S. Department of Agriculture, government laboratories sponsored research and the 1914 Smith-Lever Act created a nationwide network of locally rooted agricultural experiment stations and extension agents to ensure that all farmers would get ongoing access to trustworthy scientific information tailored to local crops, soil conditions, pests, and weather conditions.

- Extension agents worked with farmers in each area to gather information about what worked and what didn't – and then funneled data back to laboratories at state universities and the U.S. Department of Agriculture, where scientists did ongoing research to improve agricultural productivity.

Not only did this system boost farm incomes and support America's rise to global economic power, it ended up being emulated by other nations to encourage manufacturing. For example, to offer small and mid-sized manufacturers a variety of independent services, Japan's 180 *kohsetsushi* centers were self-consciously modeled on U.S. agricultural extension services. These centers employ more than 6,000 investigators and engineers who offer technology demonstrations, technical assistance, and training. Like U.S. agricultural extension agents, they also help firms to collaborate with each other and with their larger counterparts. Japan's centers helped to boost the country's manufacturing sector, as did similar centers in Germany.

Twenty-first-century U.S. leaders looking for new ways to foster economic innovation would do well to keep these powerful examples in mind. Today, there is a temptation to think only in terms of mega one-off projects – such as the big-boom investments in new research about robotics, bio-manufacturing, and materials design supported by members of President Obama's Council of Advisors on Science and Technology. Big bets may well be worth making, but we need to combine a focus on the technologies of the future with sustained strategies for assisting firms to make optimal use of cutting-edge technologies that already exist, so that firms are able to innovate continuously.

Innovative Networks Now

Networked production has made twenty-first-century manufacturing more like traditional U.S. agriculture. Just like family farmers in the U.S. past, tens of thousands of decentralized firms, scientists, and entrepreneurs face considerable uncertainty as they collaborate with various network partners to transform ideas into products. Well-designed and targeted government programs can help reduce the uncertainty and make these networks more productive.

Certain U.S. programs along the lines we advocate are already proving their effectiveness at encouraging marketable innovations:

- Innovations in the internet and the computer industry have been spurred by **the Defense Advanced Research Projects Agency**, launched in 1958 under President Dwight Eisenhower to encourage new technologies with military applications. This agency works in significant part by helping firms make the connections with one another that they need to crystallize innovations. Public sector technology officers from the Defense agency help firms locate other actors with relevant competencies. They also validate the competence of firms that have potentially exciting new ideas, raise the skill levels of firms within networks, and serve as honest brokers helping firms to negotiate cooperative agreements on intellectual property or subcontracting arrangements.

- On the civilian side, the federal government does have a small but effective manufacturing effort similar to the one that Japan developed after learning from U.S. agricultural extension programs. America's **Manufacturing Extension Partnership** was started in 1989 and has developed 56 state and local centers to help small and mid-sized manufacturers make connections and share knowledge. Results are promising, but President Obama's 2012 budget request asked only for very modest funding, just enough to support 1,400 field staff. At this size, the agency can work with only a tiny fraction of the 262,000 small manufacturing firms in the U.S. – and under its current mandate, it is not allowed to work with larger firms at all.

The costs of doing too little are well-illustrated by the recent difficulties of the U.S. advanced battery industry. In 2009, the stimulus legislation included funds to help U.S. firms produce advanced lithium-ion batteries to run electric vehicles. But the relevant scientific and technological knowledge has been monopolized by firms in East Asia, with limited access for many American producers.

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If the United States had already created a stronger Manufacturing Extension Partnership with the resources and mandate to provide services to large as well as small firms, it could have been mobilized to assist the battery companies and make the stimulus investments work better. As it happened, federal authorities scrambled to find another, ad hoc way to help. In 2010, the Argonne National Laboratory teamed up with the state of Kentucky to launch a specialized facility called the Kentucky-Argonne Battery Manufacturing Research and Development Center in Lexington, Kentucky.

A Five-Step Agenda for U.S. Advanced Manufacturing

Our proposal calls on the United States to move beyond ad hoc, patchwork solutions – to take a proactive approach to fostering advanced manufacturing networks that connect firms to one another and ensure access to the latest research, trained workers, and scarce materials.

Following historically successful examples, we need programs and structures that combine the best aspects of decentralization and centralization. **Here are five specific steps that can and should be taken right now.** Singly and together, they address concrete barriers to maximizing innovative production in America's nascent advanced manufacturing sectors – and all of these steps, wherever possible, build upon and extend efforts that have already proven their worth and promise.

(1) Expand the Manufacturing Extension Partnership.

Specifically, we should increase this proven program's budget by tenfold over the next five years. Even as the program retains a primary focus on small and medium-sized firms, it should also be mandated to work with larger firms struggling with advanced technologies. The Manufacturing Extension program already has 56 regional centers, and the most successful should be expanded two or three-fold. The total number of centers should be doubled. The goal should be to ensure that every U.S. city with more than 150,000 people would have a Manufacturing Extension center nearby, so that state-of-the-art data and information can be shared among well-networked firms.

(2) Fund advanced laboratories run by the National Institutes of Standards and Technology.

Each of these facilities would have a somewhat different specialty – for example, one would focus on robotics, another on continuous process technologies, and a third on nano-scale production. These laboratories would assemble scientists and engineers from government and industry together to solve actual production problems. Teams from the Manufacturing Extension Partnership working with particular firms in their regions would be able to get advice on the most intractable problems – and the practical experiences of local firms could be conveyed to the laboratory scientists and engineers.

(3) Create a network of smaller, specialized manufacturing laboratories.

These can be along the lines of the National Science Foundation's Engineering Research Centers. Following the example of agriculture, these labs should be located on university campuses and maintain ongoing connections to the larger national laboratories and the regional manufacturing extension agents. A plan to launch twelve of these collaborative manufacturing institutes is already part of the Obama administration's advanced manufacturing strategy.

(4) Establish a National Center for Advanced Manufacturing Skills.

The Manufacturing Extension Program already works with community colleges and other local institutions to provide the up-to-date training and skills that workers must have in today's advanced manufacturing. These efforts would be greatly enhanced by setting up a National Center for Advanced Manufacturing Skills, with professionals who could work with the various laboratories and manufacturing extension agents to develop teaching material and curriculums for local institutions. Over time, this agency would be able to anticipate emergent industry needs, so that innovative skills and production facilities could be developed at the same time.

(5) Ensure access to scarce materials needed in advanced production.

In recent years, U.S. manufacturing firms have faced shortages in key supplies – as, for example, when the Chinese limited exports of rare earth elements vital to several advanced production processes. A new National Center for the Analysis of Supply Chains could develop the expertise to track key inputs needed for the advanced manufacturing sector. The agency would focus on analysis and dissemination of findings, yet it could also serve as an early warning system for industry and government alike, anticipating possible bottlenecks and helping find strategies to address bottlenecks.

Taken together, the five steps we recommend would spur entrepreneurialism and creativity in U.S. advanced manufacturing, and enable America's producers to keep pace with savvy competitors abroad. Government would play a sustained and active role in the strategy we outline, but investors, manufacturers, engineers, and skilled workers would provide the inputs and energy.

Big Benefits at Modest Cost

How much would our agenda cost? Overall, we estimate that the five steps we outline would require about $5 billion in additional federal funds per year, when the efforts are fully up and running. The ramp up over several years would start at a lower level and move to that full-funding plateau. The price-tag may seem hefty, but it is tiny in relation to the size of America's overall manufacturing production – and the new investments we suggest would pay for themselves many times over.

The current total of U.S. manufacturing gross domestic product is about $1.6 trillion each year. That means that our five-step program would only need to lift manufacturing productivity by four-tenths of one percent each year to fully pay for itself. But the potential annual productivity gains for advanced manufacturing – appropriately spurred forward by well-tailored U.S. government support – would surely be much larger.

Research on historical increases in U.S. agricultural productivity has determined that agricultural extension agents were able to have very dramatic impacts on productivity rates – by diffusing best practices even to relatively small and out of the way farms.

Similar possibilities to boost productivity beckon today in advanced manufacturing. Many studies show that productivity varies hugely across enterprises. Fostering innovative networks and providing extension services as we propose would help many of the less productive firms speed up to at least industry averages. This would give a big boost to overall U.S. economic productivity while at the same time creating good new jobs and strengthening America's national security.

The time has come, in short, for America to do once again for firms in advanced manufacturing what it earlier did for farmers and scientific agriculture. At modest cost for big benefits, our government can play a positive role by fostering and sustaining the vital networks from which growth and innovation flow.

Selected Sources and Further Reading

** Fred Block and Matthew R. Keller, eds., *State of Innovation: The U.S. Government's Role in Technology Development.* Boulder, Colorado: Paradigm Publishers, 2011.

Provides an overview of the extensive initiatives in the U.S. that help firms move technologies from the laboratory to the commercial space.

** Susan Helper and Marcus Stanley, "Creating innovation networks among manufacturing firms: How effective extension programs work," pp. 50-62 in *Economic Development Through Entrepreneurship: Government, University and Business Linkage*, edited by Scott Shane. New York: Edward Elgar, 2007.

Explains how manufacturing extension programs can make significant contributions to manufacturing productivity.

** Andrew Schrank and Josh Whitford, "The Anatomy of Network Failure." *Sociological Theory* 29, no. 3 (2011): 151-177.

Explains why networks have become so central and why they fail on a routine basis when network partners fail to meet their partner's expectations.

** Philip Shapira, "Putting Innovation in Place: Policy Strategies for Industrial Services, Regional Clusters, and Manufacturing SMEs in Japan and the United States." Prometheus 26, no. 1 (2008):69-87.

Contrasts Japan and the United States, and shows how Japan provides a broader range of services to established small enterprises in manufacturing.

** Josh Whitford, *The New Old Economy: Networks, Institutions, and the Organizational Transformation of American Manufacturing.* New York: Oxford, 2006.

Documents the reorganization of heavy manufacturing in the Upper Midwest and discusses the role that manufacturing extension can play in helping subcontractors deal with big firms.