Manufacturing dominates global trade and is the basis for export-led development. A nation's capacity to transform physical raw materials into products valued by end users all over the world has been the hallmark of economic development for more than two centuries. Although trade in intangibles and services has grown rapidly in recent decades, no country has yet been able to leapfrog successfully from exporting raw materials into the global information economy without “making stuff” for international markets along the way.

Export-led development among follower nations puts pressure on leading nations. If the leaders can continue to innovate and differentiate their output, mutually beneficial exchange of the sort typically described in economics textbooks may result. However, “hollowing out” of the leaders (that is, the sudden decline of their key sectors) is not an impossible outcome, either theoretically or in practice; global economic leadership has changed hands from time to time throughout the course of modern history. Where any particular historical episode comes out along the spectrum, from Pareto optimality to hollowing out, depends on many factors; one of the most important is the public policy response of the leading nation.

The United States faces such a challenge today. As this paper describes, the U.S. manufacturing sector contracted severely in the 2000s, raising the prospect that important manufacturing industries—both high tech and low tech—might disappear from the country for good. The Great Recession that began in 2008, which was brought on by both domestic and international forces, punctuated this decline. The U.S. response to the recession staved off immediate disaster, and it has created momentum toward an effective response to the longer-term challenge. As I argue below, whether this momentum will be sustained is an open question, but if the United States does retain its leading position in manufacturing, the challenge may then be reversed. Export-led growth in follower countries could stall, thereby

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posing a new set of policy questions. This potential outcome, which to my mind calls for a collaborative international response, is explored in the conclusion of this paper.

THE DEATH OF MANUFACTURING IN THE U.S. HAS BEEN EXAGGERATED . . . BUT NOT BY MUCH

The U.S. became the global leader in manufacturing in the late 19th century, surpassing Great Britain in output and productivity. After World War II, when its economic competitors lay prostrate, the United States dominated global industrial production to a historically unprecedented degree. In the second half of the 20th century, these competitors recovered and new ones came on the scene, which diminished U.S. dominance. Nevertheless, the U.S. manufacturing sector remained the world’s largest through the end of the century. Moreover, it led the way in creating high-tech, high-value manufacturing industries, from computers to aircraft to biotechnology.

Something happened around the turn of the 21st century. The slow decline in U.S. manufacturing employment, which had averaged .5 percent per year for the previous two decades, accelerated to 4.3 percent per year in the 2000s. In all, one-third of U.S. manufacturing jobs evaporated during the “lost decade.” Investment shriveled, and the capital stock of many U.S. manufacturing industries actually shrank. While low-tech industries were hit the hardest, high-tech manufacturing was not immune. The U.S. trade balance in advanced technology products, one indicator of U.S. competitiveness in high-tech manufacturing, turned negative for the first time in 2002; by 2010 it was running almost $100 billion in the red.

This sharp downturn in the fortunes of U.S. manufacturing is explained in part by China’s growing role as the “factory for the world.” The Chinese government supported in a variety of ways the export of goods made both by domestic manufacturers and by international firms that built factories in China. Perhaps most important was China’s commitment to an exchange rate that substantially undervalued the yuan relative to the dollar throughout most of the first decade of the 21st century. China’s rise provoked a herd mentality among international firms to shift production there, even when rational analysis suggested that such a move might ultimately be counterproductive.

As a result of its trade imbalance with the U.S., China accumulated an enormous stock of U.S. dollars, much of which it parked in U.S. treasury bonds, which added liquidity to the U.S. economy. These flows contributed to the U.S. housing boom of the mid-2000s, and they were amplified by a mania that inevitably became—in the words of Charles P. Kindleberger’s classic analysis—a panic that triggered the recession. A massive misallocation of capital was thus followed by an extreme credit crunch. By the end of 2008, U.S. manufacturers were shedding 150,000 jobs per month, and both General Motors and Chrysler were plunging toward bankruptcy.
The Future of Manufacturing

SEEDS OF RECOVERY

The U.S. economy and its manufacturing sector hit bottom in 2009. Since the beginning of 2010, U.S. manufacturers have added more than 500,000 jobs, helping to lead the overall economy out of recession. Although this gain represents just a small fraction of the six million jobs lost in the 2000s, the present recovery is the strongest sustained period of growth in manufacturing employment since the technology boom in the mid-1990s.11 Like the downturn, the recovery is being driven by both domestic and international factors.

The Obama administration’s 2009 intervention in the auto industry was a critical contribution to the recovery. The managed bankruptcies of General Motors and Chrysler stabilized expectations and avoided a pell-mell dismantling of industrial capabilities that would have been very difficult to reassemble later. “Cash for clunkers,” which subsidized the exchange of old cars for new, and other federal programs buoyed demand for autos through the trough of the recession. Pent-up demand for cars then helped to carry the recovery forward. The auto sector accounted for about a quarter of the growth in industrial production in the first two years of the recovery, five times its share of total production.12

A second domestic factor driving the manufacturing recovery has been the boom in “unconventional” natural gas. Nearly a quarter of U.S. natural gas production now comes from unconventional sources, generally horizontal wells made productive by the hydraulic fracturing of shale.13 These processes use pipes, drilling equipment, and other manufactured goods, which has stimulated a large supply chain. Furthermore, the abundant supply of natural gas has driven gas prices to record lows, inducing investments by manufacturers that are energy intensive or that use it as a feedstock.

On the international side of the ledger, U.S. labor costs have become more competitive, in part due to falling compensation at home but more significantly due to rising costs abroad.14 Wages in Chinese coastal cities, for instance, where exporters of manufactured goods are concentrated, are rising exponentially without concomitant gains in productivity.15 At least as important is the fact that the psychological hold off-shoring has had on corporate strategists seems to have been broken. As a team from the Brookings Institution put it recently, “American firms are now more likely to appreciate ‘hidden costs’ of production abroad, such as administrative costs, legal costs, risks and complexities.”16

LONGER-TERM PROSPECTS

Forceful action by the U.S. government prevented the recession from becoming another Great Depression. It preserved the domestic auto industry and reaped the good fortune of shale gas development and increasing overseas unit labor costs. However, the forces that have been fueling the recovery in the short term are not necessarily sustainable over the long term: pent-up demand will exhaust itself, the
terms of trade are volatile, and innovations that are making natural gas cheap in the U.S. will eventually make it cheap in other locations, too.

Nevertheless, there are reasons to believe that the short-term recovery in U.S. manufacturing can be converted into a longer-term revival. In order to make this transition, the U.S. will need to capitalize on emerging technological opportunities that play to the country’s comparative strengths, notably its flexibility, its knowledge base, and its entrepreneurial skills. As the nongovernmental Council on Competitiveness put it, “U.S. firms are at the forefront of new technologies, production processes, customized manufacturing and the use of high performance computing that could lead to a manufacturing renaissance.”

A recent study by the IDA Science and Technology Policy Institute for the U.S. Office of the Director of National Intelligence identifies several trends that will lead manufacturers to “rely less on labor-intensive mechanical processes and more on sophisticated information-technology-intensive processes.” One example is additive manufacturing, in which products are built up layer by layer through material deposition, instead of being carved out of larger blocks of material or bent into position. This approach has the potential to save on labor, materials, energy, and capital in manufacturing a wide range of existing products, and it is also yielding new kinds of products that cannot be made with existing processes.

A second example is modeling and simulation. The dropping cost of information technology and the development of sophisticated software increasingly allow producers to explore process and product design alternatives in great detail before building factories or even prototypes. Modeling and simulation can optimize the use of inputs, customize outputs, and avoid unexpected bugs that cost time and money. While large firms have been able to access these capabilities for some time, they are increasingly available to the vast number of small and midsized enterprises that make up a large fraction of U.S. manufacturing.

Other potentially game-changing technologies cited by the Science and Technology Policy Institute and other analysts include biomanufacturing, nanomanufacturing, advanced materials, robotics, and intelligent controls. The integration of diverse components into novel production systems that can respond rapidly and precisely to customer demands is perhaps the biggest opportunity of all. It is no surprise that manufacturing executives rank innovation among their highest priorities today.

**TURNING OPPORTUNITY INTO REALITY**

Although many of these new manufacturing technologies have been invented in the United States, there is no guarantee that the production facilities that use them on a large scale and the supply chains that support them will take root in this country. The United States excels at generating radical new technologies and spawning companies that bring them to market, but its ability to sustain innovation and foster incremental improvements in manufacturing processes and systems of production has eroded in recent decades.
The pattern of “invent here, produce there” has played itself out across a variety of industries, from computer hardware to composite materials to automobile components. The gains to the first mover have diminished in the intervening period. More countries have moved to the technological frontier, and the pace of adoption and indigenization of innovations by followers has accelerated. Governments around the world today see advanced manufacturing technologies as important targets for investment.

To turn the opportunity new manufacturing paradigms present into the reality of domestic economic activity and jobs, the United States will have to break this pattern. Doing that will entail new public policies that allow U.S. manufacturing enterprises to access key resources for process and supply-chain innovation quickly and easily. But some of these resources—including worker skills, shared infrastructure, and the results of applied research and demonstration projects—do not fit comfortably into the conceptual framework that has traditionally guided U.S. economic policy.

This conceptual framework classifies goods as either public or private and puts responsibility for providing them in the corresponding sector. According to this framework, basic research, for example, is a public good and therefore should be government funded; product development, in contrast, is a private good and should be funded by firms. Advanced manufacturing process-innovation resources do not fit into these conceptual boxes very well, as they provide benefits that often cannot be captured fully by either individual firms or the general public. Instead, their benefits are shared within an industrial or regional community that has both public and private components. The “industrial commons,” as Pisano and Shih have labeled such resources, is therefore best supported by public and private co-investments.

The skills of production workers are an example. Many U.S. manufacturing firms used to maintain internal promotion ladders for workers that were supported by major investments in training. They could do so secure in the knowledge that their commanding place in the market would let them reap the benefits of these investments and allow them to share these benefits with workers in the form of high compensation. This kind of privately funded training is far less common now, and a hodgepodge of community college and certification programs has taken its place. These programs must be paid for mainly by the workers themselves, who may not have the confidence that such an investment will pay off and may not have the money to cover these costs, even if they would like to. The pools of highly skilled labor that once were a key part of the industrial commons in manufacturing-intensive regional economies around the U.S. thus have shrunk to the point that manufacturers say that skill shortages are a major constraint on expansion and make it hard to introduce process innovations.

Practical knowledge about and experience with innovative manufacturing processes is another element of the industrial commons that the United States has trouble producing. Here, too, an older model of vertical integration has broken...
down, but a new model has not emerged to replace it. Firms that once willingly took the risk of introducing and debugging new processes are less willing to do so now. The expected returns to individual manufacturers from taking such risks have declined as competition has intensified; many have outsourced production in order to avoid them.

Few institutions have stepped into this breach. U.S. universities generally reward scientific novelty rather than manufacturing process expertise. Government laboratories have typically been kept at arms’ length from firms outside the defense sector. Independent organizations, whether for profit or non-profit, rarely have been able to sustain manufacturing process innovation as a major line of business. “The mysteries of industry,” which Alfred Marshall famously wrote in 1890 are “in the air” in dynamic industrial districts, are less widely available in the contemporary United States than in the past.

As Ricardo Haussman and Cesar A. Hidalgo state:

A laissez-faire disregard of the government-provided requirements for competitive manufacturing, justified under the often repeated prohibition against “picking winners” is bound to guarantee that a country will end up losing the march towards prosperity by making public-private cooperation impossible in constructing the productive ecosystem.

Key U.S. competitors employ conceptual frameworks less beholden to this prohibition and thus have been able to implement policies toward training, research, and other key resources that are better aligned with the needs of cutting-edge production. Invent here, produce there remains a very real possibility that the U.S. will have to deal with as the emerging manufacturing technologies of today mature.

INITIAL STEPS AND HEADWINDS
The Obama administration has recognized that the short-term recovery in U.S. manufacturing hardly ensures the renaissance hoped for by the Council on Competitiveness. The president singled out manufacturing in his 2012 State of the Union address as an economic activity that deserves particular attention from the U.S. government. His senior economic advisor, Gene Sperling, responding to the criticism that the president was picking winners, set forth the case for a long-term strategy in more technical detail a couple of months later, arguing that manufacturing “punches above its weight” and is therefore “worthy of a special emphasis in the Obama economic strategy.”

The administration has proposed a substantial infusion of federal resources into advanced manufacturing. The president’s fiscal year 2013 budget proposal, for instance, asks for a 19 percent increase in manufacturing R&D spending, which would bring growth over the last two years to more than 50 percent. It calls for an $8 billion investment in community college-based training programs across a number of fields, including advanced manufacturing, building on a $2 billion expenditure in the 2009 stimulus package. The president also seeks to reform the
federal tax code to support domestic manufacturing and related R&D investments more effectively.

More crucial than the spending and taxation proposals, however, are the administration’s efforts to change the way federal resources would be invested. In June 2011, responding to recommendations from his Council of Advisors on Science and Technology, President Obama established an Advanced Manufacturing Partnership (AMP) made up of federal agencies, leading engineering universities, and major manufacturers. The goal of the AMP is “to invest in the emerging technologies and skills that will support a dynamic domestic advanced manufacturing sector.”

The partnership approach is implemented in the training area through grants that require community colleges to work with local employers to define skill sets for which employers anticipate a demand. New federal programs also seek to build advanced manufacturing partnerships at the regional level, which include the participation of state and local economic development organizations, and within industries to develop collaborative strategies and devise technology roadmaps.

The AMP’s most ambitious thrust is a proposal to create a National Network for Manufacturing Innovation, which would be made up of about 15 large-scale public-private institutes that would provide education and training at all levels, engage with small and midsized manufacturers, and conduct collaborative research, development, and demonstration projects. A pilot institute for the proposed network in the area of additive manufacturing was awarded to a public-private consortium based in Youngstown, Ohio, in August 2012. Establishing the full network would require congressional approval.

The steps that have been taken to date are promising, but they are not very big. The administration’s proposals are more sweeping, but they have not been enacted. Like President Bill Clinton, who sought to make similar conceptual and programmatic changes 20 years ago, President Obama faces powerful headwinds. One headwind comes from defenders of the prohibition against picking winners. Christina Romer, who chaired the White House Council of Economic Advisors in the first two years of the Obama administration, published a critique along these lines in the New York Times within a couple of weeks of the 2012 State of the Union address. Republicans in Congress and on the presidential campaign trail have charged that President Obama is engaging in “crony capitalism.” A second headwind is the federal budget situation; the Republican-controlled Congress has clamped down on spending across the board, pitting Democratic priorities against one another. The zero-sum environment forces difficult choices, and existing programs whose constituencies are threatened by cutbacks often have an edge over new initiatives in such situations.

Still, the president can draw from a deep reservoir of public support in advocating for his proposals. In a 2011 poll, for instance, 83 percent of respondents in a nationally representative sample agreed or strongly agreed with the statement that the “U.S. needs a more strategic approach to the development of its manufacturing base.” Moreover, manufacturing is broadly dispersed across the country, a
critical consideration in a geographically based political system. The Republican-dominated South, like the more bipartisan Midwest and Democratic-controlled New York and California, suffered significant losses of manufacturing jobs in the past decade. A sustainable, bipartisan approach to manufacturing is thus not beyond the realm of possibility, if and when the poisonous atmosphere that pervades U.S. politics in this election year dissipates.

GLOBAL IMPLICATIONS

If the United States were to successfully revitalize its manufacturing sector with a strategy that emphasizes process innovation as well as novel products, its success would have major implications for the rest of the world. On the positive side of the ledger, customers overseas as well as at home would be able to buy old goods more cheaply and gain access to goods that had previously been unavailable. In addition, the new production paradigms would likely be more environmentally sustainable at both the local and global levels than those they would replace.

Positive spillover from a U.S. manufacturing revival might outweigh any costs imposed on the rest of the world. Such a scenario would require that other countries adjust their own manufacturing strategies so they would complement the U.S. strategy. However, it is also possible that those costs would be considerable and lead to economic and political disruption. In extreme cases in the past, contests for global industrial preeminence have contributed to international conflict.

One worrisome if unlikely scenario would be that the United States achieved such success that it blocked the industrial development of other countries. Just as factory production in the 19th century displaced home-based craft production, so too could additive or bio- or nanomanufacturing in the 21st century displace older systems of making materials or consumer goods, or even complex industrial products. Because manufacturing jobs often have been the first rung of the ladder out of poverty, established development strategies would be upended in such a scenario.

A variation on this scenario would be that U.S. success leads to a degradation of labor and environmental standards abroad. If other nations believe they will be unable to compete on the new production frontier, some manufacturers might simply cut corners in their established production processes by cutting wages, relaxing safety standards, or polluting more. This variation, like the previous one, raises difficult questions of justice and responsibility in global capitalism.

An alternative scenario posits countries racing to encourage their manufacturers to imitate or even, as President Obama put it in his 2011 State of the Union address, to “out-innovate” one another. In its benign form, such a race would simply accelerate the global diffusion of the positive spillover of the new technologies. But it also could lead to government subsidies that create global overcapacity and, thus, volatility. Or, it could lead to trade protections that fragment global markets and undermine incentives for innovation.
The Future of Manufacturing: The United States Stirs

Perhaps all of these scenarios will play out in different ways across different manufacturing industries. There is no reason to think that the dynamics of auto parts would be the same as those of chemicals or semiconductors. Indeed, there is no reason to think that the “renaissance” of U.S. manufacturing would be pervasive, even if the proposed national strategy proves fundamentally sound. Manufacturing is an enormous and varied sector about which it is intrinsically difficult to generalize.

Still, these crude scenarios highlight the fact that national manufacturing strategies are interdependent, and they suggest that some of the risks of this interdependence might be managed through international collaboration. The World Trade Organization, for instance, has some power to limit the risks posed by protectionism. There is no such entity, however, with the power to manage the risks posed by overcapacity, labor exploitation, or pollution.

The United States and its challengers will therefore likely need to find new ways to cooperate if tomorrow’s global manufacturing economy is to realize its full potential. As the world’s largest economy and richest country, the United States will undoubtedly have to take a leadership role if such cooperation is to occur. Even though the country is preoccupied now with crafting an effective and sustainable response to the competitive challenge, its leaders must not lose sight of their global as well as national responsibilities.

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32. “Ensuring American Leadership in Advanced Manufacturing,” President’s Council of Advisors on Science and Technology, June 2011.
38. Atkinson et al., “Worse Than the Great Depression.”