Metropolitan Policy Program
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Why Does Manufacturing Matter? Which Manufacturing Matters?
A Policy Framework

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"Public policy is needed to help strengthen manufacturing and promote a high-wage, innovative, export-intensive, and environmentally sustainable manufacturing base."

Summary

Manufacturing matters to the United States because it provides high-wage jobs, commercial innovation (the nation's largest source), a key to trade deficit reduction, and a disproportionately large contribution to environmental sustainability. The manufacturing industries and firms that make the greatest contribution to these four objectives are also those that have the greatest potential to maintain or expand employment in the United States. Computers and electronics, chemicals (including pharmaceuticals), transportation equipment (including aerospace and motor vehicles and parts), and machinery are especially important.

Productivity and wages vary greatly within as well as between industries. In any industry, manufacturers that are not already at the top have room to improve their performance by adopting "high-road" production, in which skilled workers make innovative products that provide value for consumers and profits for owners.

American manufacturing will not realize its potential automatically. While U.S. manufacturing performs well compared to the rest of the U.S. economy, it performs poorly compared to manufacturing in other high-wage countries. American manufacturing needs strengthening in four key areas:

- Research and development.
- Lifelong training of workers at all levels.
- Improved access to finance.
- An increased role for workers and communities in creating and sharing in the gains from innovative manufacturing.

These problems can be solved with the help of public policies that do the following:

- Promote high-road production.
- Include a mix of policies that operate at the level of the entire economy, individual industries, and individual manufacturers.
- Encourage workers, employers, unions, and government to share responsibility for improving the nation's manufacturing base and to share in the gains from such improvements.

Introduction

The United States lost 41 percent of its manufacturing jobs between June 1979, when manufacturing employment peaked and December 2009, when it reached its recent low point.[2] The last decade saw the most severe manufacturing job losses in U.S. history. Manufacturing's share of total employment fell from 13.2 percent in January 2000 to 8.9 percent in December 2009.[3]

During the last two years there have been some positive signs for manufacturing. The number of manufacturing jobs increased by 2.6 percent from December 2009 through September 2011, and these gains were concentrated in durable goods manufacturing, which is generally the higher-wage, more productive part of manufacturing.[4] In addition, between 2009 and 2010 manufacturing output grew at more than double the rate of GDP. However, the recent manufacturing job gains pale in comparison to the losses since 2000; at the rate of manufacturing job growth that the nation has seen since December 2009, it would take until 2037 for the nation to regain all the manufacturing jobs it lost between January 2000 and December 2009.[5] Moreover, inflation-adjusted hourly wages in manufacturing fell between December 2009 and September 2011, even as manufacturing employment was growing. Manufacturing wages declined more rapidly than wages in the private sector as a whole.[6] Thus, even if recent job growth continues, all is not well with American manufacturing.

There has recently been renewed debate over whether, as Stephen Cohen and John Zysman argued in their 1987 classic, "manufacturing matters" to the U.S. economy.[7] In the current debate, some argue that manufacturing job loss should not be a public policy concern because it results from rapid productivity growth, which is good for the national economy.[8] Others contend that there is nothing special about manufacturing because many service industries can be just as productive and innovative as manufacturing.[9] A final argument against a renewed policy focus on manufacturing is that U.S. manufacturing wages are too high for manufacturing to be internationally competitive.[10] On the other side of the debate are those who argue that manufacturing is a crucial source of high-wage jobs and innovation and is essential if the United States is to reduce its trade deficit, maintain a strong national defense, and have a thriving service sector.[11]

This report argues that manufacturing does indeed matter to the U.S. economy and that public policy can strengthen American manufacturing. The nation need not and should not passively accept the decline or stagnation of manufacturing jobs, wages, or production. American manufacturing matters because it makes crucial contributions to four important national goals.

- Manufacturing provides high-wage jobs, especially for workers who would otherwise earn the lowest wages.
- Manufacturing is the major source of commercial innovation and is essential for innovation in the service sector.
- Manufacturing can make a major contribution to reducing the nation's trade deficit.
- Manufacturing makes a disproportionately large contribution to environmental sustainability.[12]

This report provides new and detailed evidence in support of these arguments.

The report also rebuts each of the main arguments made by those who say that the United States should allow its manufacturing sector to shrink. It shows that U.S. manufacturing job losses are not due primarily to rapid productivity growth in manufacturing. Although some service industries are highly productive and innovative, only a small share of non-manufacturing employment is more productive or innovative than the manufacturing average. Finally, American manufacturing wages are not too high for U.S. manufacturers to be internationally competitive.

Unlike other reports, this report not only explains the important public purposes that manufacturing serves ("why manufacturing matters"), but also "which manufacturing matters": which kinds of manufacturing jobs the nation has the greatest potential to retain or grow and which kinds of manufacturing firms are most likely to prosper in a way that promotes high wages, innovation, more balanced international trade, and a better environment. This report shows:

- The industries and firms that support the four national goals identified in this report are also those that have the greatest potential to maintain or expand employment in the United States. Computers and electronics, chemicals (including pharmaceuticals), transportation equipment (including aerospace and motor vehicles and parts), and machinery are especially important for their contributions to the four national goals and their job-retention or job-creation potential.

- There is dramatic variation in productivity and wages among firms in the same industry as well as between industries. Thus, even within industries that have low productivity and wages on average, firms that are not already at the top have room to improve their performance. They can do so by adopting a "high-road" production recipe, in which skilled workers make innovative products that provide value for consumers and profits for owners.

American manufacturing will not realize its potential automatically, however. While U.S. manufacturing performs well compared to the rest of the U.S. economy, it performs poorly compared to manufacturing in other high-wage countries. U.S. manufacturing wages are relatively low by international standards, the American edge in innovation and renewable energy manufacturing is slipping, and manufacturing runs a huge trade deficit (rather than a surplus, as in many other high-wage countries). Public policy is needed to help strengthen manufacturing and promote a high-wage, innovative, export-intensive, and environmentally sustainable manufacturing base.

Unlike other Brookings work on manufacturing policy, this report does not suggest particular policies but frames the terms within which manufacturing policy should be designed.[13] To achieve the national goals that this report emphasizes, American manufacturing needs strengthening in four key areas:

- Research and development, including that needed to solve problems common to a variety of manufacturing processes, not just that needed to develop "breakthrough" products.
- Lifelong training of workers at all levels, so that they are equipped to collaborate in designing and implementing innovative products and processes.
- Improved access to finance for firms wishing to make productive investments.
- Mechanisms that increase the role of workers and communities in creating and sharing in the gains from innovative manufacturing.

These problems can be solved with the help of public policies that do the following:

- Promote "high-road production," in which firms harness the knowledge of all their workers to create innovative products and processes.
- Include a mix of policies that operate at the level of the entire economy, individual industries, and individual manufacturers.
- Encourage workers, employers, unions, and government to share responsibility for improving the nation's manufacturing base and to share in the gains from such improvements.

Our policy framework is unabashedly but not uncritically pro-manufacturing. Manufacturing matters for public policy because it serves important public purposes, and policy should improve the extent to which it does so. Policies designed to strengthen manufacturing, or particular manufacturing industries or firms, should promote the achievement of those purposes. Not every manufacturing firm or industry is equally able to contribute to the achievement of those purposes, even with the right kinds of policy assistance. Not every manufacturing job can or should be saved. Because there are differences within as well as between industries in the extent to which manufacturers contribute to the achievement of these national goals, a national manufacturing policy requires an understanding of the advantages and challenges that different industries, as well as different firms with different "production recipes," have in doing so.

Manufacturing policy in Germany is framed in terms similar to those proposed in this report. Combining economy-wide measures with support for industry-specific institutions and assistance to individual manufacturers, German policy promotes a manufacturing sector in which highly paid, skilled workers make innovative products that provide value for consumers, profits for owners, and contributes to a better environment and a trade surplus for the nation. This report concludes with a survey of German policy, not to advocate a wholesale transfer of that policy to the United States but to show that it is possible to use our policy framework to design successful manufacturing policies.

A. Why Does Manufacturing Matter?

Manufacturing serves critical public purposes that make it indispensable to the U.S. economy. It remains a source of high-wage jobs for virtually all types of workers, but especially for those who would otherwise earn the lowest wages. These high-wage jobs do not make U.S. manufacturing internationally uncompetitive; several other countries have higher manufacturing wages than the United

States but have had less severe losses of manufacturing jobs. By increasing productivity, the United States could increase both the average wage and the number of manufacturing jobs; productivity growth is associated with gains (not losses) in manufacturing jobs. Manufacturing is the major source of commercial innovation in the United States, including innovation in the service sector. It accounts for the majority of U.S. foreign trade and is essential if the United States is to make major reductions in its trade deficit. Finally, manufacturing makes an outsized contribution to America's "clean economy"—the goods and services that contribute to environmental sustainability. This section of the report shows the contributions that manufacturing, and individual manufacturing industries, make to these public goals.

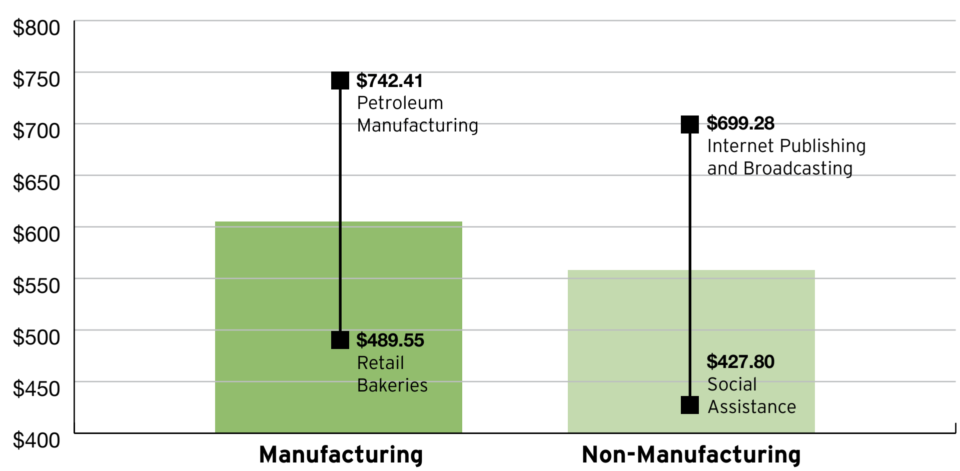
1. Manufacturing Continues to Provide High Wage Jobs, Especially for Workers Who Would Otherwise Earn the Lowest Wages

Manufacturing workers earn more than those in other industries. Weekly earnings in manufacturing during the period 2008-2010 averaged $943.06, 19.9 percent higher than the non-manufacturing average of $786.40.[14]

Because earnings depend on a variety of characteristics of workers and jobs, a straight comparison of earnings may not accurately reflect the difference in wages that any particular worker could expect to earn if he or she moved between manufacturing and non-manufacturing industries. Therefore, this section of the report compares earnings between manufacturing and non-manufacturing industries, using regression analysis to control for the worker and job characteristics that influence earnings.[15] (See Appendix table 1 for details.) After taking those characteristics into account, manufacturing workers averaged $605.18 per week, 8.4 percent higher than the non-manufacturing average of $558.29, as shown in figure 1.

Workers at all wage levels, men and women, and those in all racial/ethnic, educational attainment, and occupational groups earned more in manufacturing than in other industries. The one exception is Hispanic workers, who earned 10 cents less per week in manufacturing than in non-manufacturing industries.[16] Controlling for education and other characteristics, our data show low-wage workers benefiting the most from manufacturing jobs and high-wage workers benefiting the least, indicating that manufacturing helps reduce wage gaps between high-, middle-, and low-wage workers. Men benefited

Figure 1. Average Weekly Earnings in Manufacturing and Non-manufacturing, Controlling for Worker and Job Characteristics, 2008-2010



Source: Analysis of combined Current Population Survey outgoing rotation groups for 2008-2010, conducted by Mark Price of the Keystone Research Center

more than women, whites and Asians more than blacks, and workers with some college, high school diplomas, and bachelor's degrees more than other educational groups. Workers in farming/fishing/forestry and sales occupations benefited the most from working in manufacturing, while those in service and transportation occupations benefited the least.[17]

Earnings differ among individual manufacturing industries, once again controlling for worker and job characteristics (Appendix table 2). All but 12 of the 80 manufacturing industries shown in the table pay more than the non-manufacturing average; most of those 12 are bakeries and textile and apparel industries, and together they employ relatively few workers.[18] The highest-paying manufacturing industries are either technologically cutting-edge (e.g., aerospace; computer and electronics industries) or very capital-intensive (e.g., petroleum refining, tobacco), or both (e.g., pharmaceuticals), while the lowest-paying industries are neither. A wide range of manufacturing industries, mostly durable goods industries that are somewhat capital- and/or technology-intensive but not as much so as the highest-paying industries, pay more than the overall manufacturing average; among these are appliances, motor vehicles, and iron and steel.

While nearly all manufacturing industries pay more than the non-manufacturing average, only a few non-manufacturing industries pay more than the manufacturing average, controlling for worker and job characteristics. The latter include mining, utilities, Internet publishing and broadcasting, telecommunications, finance, insurance, professional and technical services, management of companies and enterprises, hospitals, and public administration.[19] Together these industries employ only about 21 percent of the nation's 116.3 million non-manufacturing workers.[20]

Manufacturing not only pays high wages; it is also more likely than non-manufacturing industries to provide employee benefits. Workers in goods-producing industries, of which manufacturing accounts for 65 percent of all jobs, are more likely than private sector workers as a whole to participate in some of the most common employee benefits, including both defined benefit and defined contribution retirement plans, paid holidays, life insurance, health insurance, and paid vacations (Appendix table 3).

Research indicates that the main reason why manufacturing wages and benefits are higher than those outside of manufacturing is that manufacturers need to pay higher wages to ensure that their workers are appropriately skilled and motivated.[21] Two dimensions of skill and motivation especially matter for manufacturers. First, manufacturers face higher costs of downtime, in part because they are more capital-intensive than other businesses.[22] To obtain qualified, motivated workers who will work to avoid this downtime, employers pay higher wages. Second, factories on average are larger than most other business establishments. This makes it more difficult and costly for factory managers to control the work process. To induce workers to take responsibility and, to some extent, manage themselves, manufacturers pay higher wages.[23]

This need for skilled and motivated workers across all occupations will remain a core feature of U.S. manufacturing. In fact, the policy approach advocated in this report (of increasing manufacturing productivity by encouraging firms to adopt the "high-road" strategy described below) would lead to increased reliance on skilled and motivated workers, thus leading to higher wages.[24]

Finally, manufacturing provides a disproportionately high number of jobs for less-educated workers. About 48 percent of manufacturing workers, but only 37 percent of non-manufacturing workers, have no formal education beyond high school.[25] Manufacturing's larger share of jobs for less-educated workers, along with the substantial wage advantage that it offers to those workers, make it an engine for boosting those workers into the middle class.

2. Manufacturing Continues to Be the Major Source of Commercial Innovation and Is Essential for Innovation in the Service Sector

Manufacturing firms are far more likely than non-manufacturing firms to introduce new products and new production or business processes. According to the National Science Foundation's 2008 Business R&D and Innovation Survey, 22 percent of manufacturing companies but only 8 percent of non-manufacturing companies introduced a new or significantly improved good or service between 2006 and 2008. The same percentages applied to manufacturing and non-manufacturing companies' use of new production, distribution, and support activity processes during that time. All manufacturing industries, including such reputedly "low technology" ones as wood products, furniture, and textiles, exceeded the non-manufacturing averages for both product and process introductions, while only a few science-and information technology-intensive non-manufacturing industries (software, telecommunications/Internet service/Web search/data processing, computer systems design and related services, and scientific R&D services) equaled or exceeded the manufacturing averages.[26]

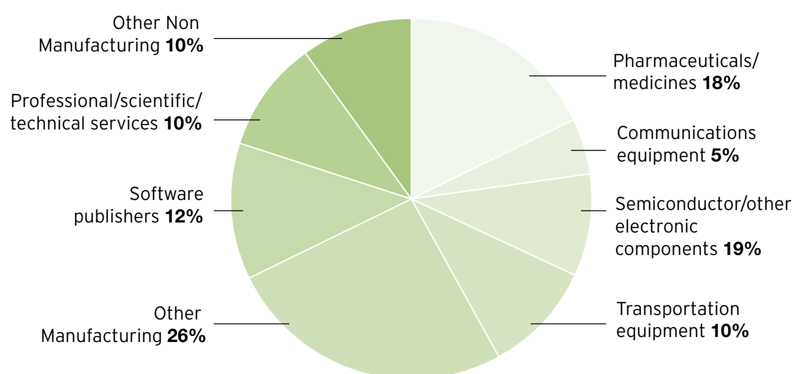
Although all manufacturing industries surpass the non-manufacturing averages, some are more likely than others to be product or process innovators. The most innovative manufacturing industries, measured by either product or process introductions, were several computer and communications industries and the pharmaceutical industry (Appendix table 4). Chemicals and the majority of durable goods industries, including autos, aerospace, and machinery, also equaled or exceeded the averages for all of manufacturing. The manufacturing industries in which both product and process introductions fell short of the manufacturing averages were wood products, nonmetallic mineral products, furniture, primary metals, beverages, food, and textiles and apparel.

Although manufacturing makes up only about 11 percent of GDP, it is responsible for the overwhelming majority of domestic research and development spending by companies, a key input into innovation. Manufacturers account for 68 percent of U.S. domestic company R&D spending.[27] The manufacturing industries that each account for at least 5 percent of the nation's domestic company R&D are pharmaceuticals (which alone accounts for 18 percent), transportation equipment, communications equipment, and semiconductors. The only non-manufacturing industries in which companies perform this much R&D domestically are software and professional/scientific/technical services (figure 2).

A similar picture emerges when examining R&D intensity (R&D spending as a percentage of sales), a measure of R&D effort that standardizes for the size of each industry. Domestic company R&D spending is 3.6 percent of domestic manufacturing sales, compared to 2.4 percent of domestic non-manufacturing sales. Among manufacturing industries, R&D intensity is highest in the computer and electronics industries and pharmaceuticals. It also exceeds the non-manufacturing average in machinery, aerospace, motor vehicles/trailers/parts, and electrical equipment/appliances/components but is below the non-manufacturing average in all other manufacturing industries (Appendix table 5).

Engineers are an essential input into technological innovation. In 2010, manufacturing employed 35.2 percent of all engineers, compared with only 8.9 percent of all workers.[28] The percentage of employment accounted for by architecture and engineering occupations (a combined category that is comparable across industries and that, in manufacturing, is 71 percent engineers) differed among

Figure 2. Industry Share of Domestic Company R&D Spending, 2006-2008



Note: Domestic company R&D spending includes all spending on R&D performed by companies in the United States and paid for by the company that performs it.

Source: Authors' analysis of National Science Foundation, Division of Science Resources Statistics, Business R&D and Innovation Survey, 2008.

Box 1. Why Official U.S. Productivity Statistics Overstate Manufacturing Productivity Growth

Mounting evidence suggests that official U.S. government statistics on productivity (from the Bureau of Labor Statistics and Bureau of Economic Analysis) overstate recent productivity growth in manufacturing. There are three reasons why they do so.

Quality improvements in computers and electronics strongly influence the growth of overall manufacturing output and productivity. According to official statistics, annual manufacturing productivity growth between 1997 and 2007 averaged 5.4 percent per year if computers and electronics are included, but only 3.2 percent if they are excluded. Computers and electronics make such a big difference because their officially measured output grew at an annual average of 22.7 percent and their productivity grew at an annual average of 26.8 percent.[29] These measured gains do not indicate that America was producing 22.7 percent more computers and electronics each year. Instead, they reflect the assumption that the quality of those products improved dramatically. This assumption is based on the fact that those products included technological advances that made them significantly more valuable.[30]

The official statistics confuse the growth of offshoring with productivity growth.[31] When people think of labor productivity increasing by 10 percent, they usually think, for example, that Joe Machinist figured out how to make 110 parts in an hour instead of 100. Instead, what has increasingly happened in the last decade is that Joe's boss offshored some production to China and fired Joe. Thus, Joe's boss is now getting 100 parts with 10 workers rather than 11, but only because of an increase in imported inputs, not because of domestic productivity growth.

The root of the problem is that value added is measured as "sales minus the cost of materials" but there are no data comparing the costs of inputs imported from different places. Without these data, there is no way to tell whether an increase in measured productivity actually reflects a value-adding change an American firm made or whether the cost of inputs simply decreased. Economist Susan Houseman and co-authors estimated that failures to capture cheaper input prices have likely accounted for 20 percent to 50 percent of manufacturing's measured growth in inflation-adjusted value added between 1997 and 2007.[32]

The official statistics confuse the growth in manufacturers' use of temporary help services with productivity growth. Since the late 1980s manufacturers have increasingly used workers employed by temporary help services to work in their factories. Although they work in factories alongside manufacturers' employees, these workers do not count as manufacturing workers in the official statistics. Yet the goods that they help produce count as manufacturing output. For this reason, manufacturers' productivity is overstated when they use temporary help services. Moreover, the growth in manufacturers' use of temporary help services means that this overstatement has become larger over time, so that the growth of manufacturing productivity is also overstated. Houseman and co-authors estimate that, in 2004, counting employment services workers as part of the manufacturing workforce would have added 8.7 percent to direct-hire manufacturing employment, compared to just 2.3 percent in 1989. As a result, they estimate, the growth of manufacturing productivity was overstated by 0.5 percentage points between 1989 and 2000 and between 2001 and 2004.[33]

Correcting for these three sources of overstated manufacturing productivity growth reduces the officially reported 5.4 percent annual productivity growth between 1997 and 2007 considerably. After adjusting for increased offshoring, manufacturing productivity growth falls to 4.8 percent annually. In addition to this, removing computers and electronics from the manufacturing total reduces productivity growth to 2.8 percent. Adding an adjustment for the increased use of temporary workers reduces it further, to 2.3 percent. However, this remains above the 1.8 percent productivity growth rate for all private business.

manufacturing industries. The transportation equipment industries (aerospace, motor vehicles and parts, and other transportation equipment), computers and electronics, machinery, electrical equipment, and petroleum and coal products had the highest percentages of their jobs in architecture and engineering occupations (Appendix table 6). These occupations made up the smallest percentages of employment (at or below the economy-wide average of 1.8 percent) in nondurable goods industries. Notably, engineers and related occupations account for a relatively small share of jobs in the pharmaceutical industry, where, unlike in other manufacturing industries, scientists are much more important than engineers in developing new products.

Patents are an indicator of invention, a key input into innovation. The U.S. Patent and Trademark Office provides industry-level patent data only for manufacturing industries, making it impossible to compare patenting rates in manufacturing to those in the rest of the economy. However, there are large differences in patenting activity among manufacturing industries (Appendix table 7). These differences reflect a combination of the extent of invention and the importance of patenting as a means of creating intellectual property rights in invention. Computers and electronics industries are the top four patenting industries; together they account for just over half of all patents of U.S. origin. Machinery, chemicals other than pharmaceuticals, and electrical equipment also accounted for more than 5 percent of all patents apiece. Nondurable goods (other than chemicals), nonmetallic mineral products, and non-automotive transportation equipment (including aerospace, which ranks high in employment of engineers) account for the fewest patents, less than 1 percent each.

Finally, labor productivity growth is a broad measure of innovation that combines the impacts of incremental and radical changes in production processes.[34] The official statistics overstate productivity growth because they do not properly account for the role of offshoring and manufacturers' use of temporary help services. They also include the computers and electronics industry, whose extremely high productivity growth rate has an outsized impact on overall manufacturing productivity growth. However, even after correcting for these factors manufacturing still has higher productivity growth than the private sector as a whole (Box 1).[35] As with other innovation measures, productivity growth in individual manufacturing industries varies greatly (Appendix table 8). Computers and electronics had by far the fastest productivity growth of any manufacturing industry. Motor vehicles and parts also had productivity growth above the manufacturing average, while miscellaneous manufacturing and apparel and leather products had productivity growth near the manufacturing average. At the other extreme, productivity growth was below the average for all private business in many nondurable goods industries, nonmetallic mineral products, and fabricated metal products. Productivity actually declined in petroleum and coal products.

These findings show that manufacturing industries contribute to innovation in very different ways. Computers and electronic products is a highly innovative industry on all the dimensions of innovation highlighted in this section, while food, beverages, and tobacco rank low on all dimensions. However, there are other industries that are high innovators on some dimensions and low innovators on others (e.g., motor vehicles and parts). In addition, because manufacturing industries on average are more innovative than the rest of the economy on every dimension discussed here, even industries that perform at or near the manufacturing average on all dimensions should be regarded as very innovative.

The high level of innovation that characterizes so much of U.S. manufacturing depends in large part on the co-location of production and R&D. Some argue that the United States can build its manufacturing economy around innovation and R&D while locating production elsewhere.[36] Yet studies of the relationship between production and innovation indicate that the location of production is an important determinant of which countries lead current and future technology cycles.

America's track record of offshoring reveals that the loss of industrial production capability often leads to later loss of R&D capability. The reason is that making products exposes engineers to both the problems and the capabilities of existing technology, generating ideas both for improved processes and for applications of a given technology to new markets. Losing this exposure makes it harder to come up with innovative ideas. For instance, U.S. firms decided to offshore battery and electronics production to East Asian countries a decade ago. Now, East Asian countries have a significant production advantage in this area, which is in part feeding their innovation advantage in the race to develop vehicles with better rechargeable batteries.[37]

Similarly, movement of semiconductor production to Asia has led to a sharp decline in thin-film-deposition production in United States. Now that thin-film-deposition has turned out to be important for manufacturing solar panels, those past decisions are causing the United States to fall behind in the quickly growing solar industry.[38]

Offshoring production stymied later innovation in the rare-earth technology industry as well.[39] The U.S. rare-earth technology industry began importing key inputs in 1975, and China replaced the United States as the main producer of rare-earth element materials by 1990. The patent application rate in the U.S. rare-earth technology industry has since dropped, indicating that innovation in this field is less likely to come from American firms. The case of rare earth metals is important because those metals have a key role in many cutting-edge products. In addition, the case is important because it is one in which it is easy to show that offshoring caused innovation to decline. As discussed above, in many industries a rise in offshoring happened at the same time that innovation capability in the United States declined. However, in many of these industries, it is difficult to show that offshoring was responsible for the drop-off in innovation; it may be that offshoring became attractive because capabilities were lagging. In the rare earth case, the latter possibility can be ruled out, because the decline of mining in the United States was due to exhaustion of deposits and environmental regulations, neither of which was related to the innovative capabilities of downstream operations.

Production of manufactured goods is also essential for innovation in America's service sector. High-technology services such as Internet services, telecommunications, computer systems design, and scientific research are closely linked to industry-funded R&D. Because America's manufacturing sector provides the overwhelming majority of the nation's industry-funded R&D and employs an outsized percentage of engineers and scientists, economist Gregory Tassey explains:

> *The ability of the domestic economy to be competitive in high-tech services will continue to require close interactions with the creators and suppliers of technologically advanced hardware and software. . . . Under a "service-sector-only" growth scenario, the skilled pool of researchers would be unavailable to the developers of high-tech services.*[40]

Even in instances when U.S. firms do maintain the technological edge without manufacturing products in the United States, this alone is not always enough to produce substantial profits. E-ink, a Massachusetts-based firm, designed and manufactured the electronic "ink" that represents the Kindle's key innovative element.[41] Because the firm was geographically located so far away from its Asian suppliers, it had trouble finding new markets for its products because its engineers were not able to interact on a daily basis with other firms in the supply chain that are inventing new products. The situation is similar throughout the rest of the LCD flat-panel-display industry. Harvard Business School Professor Willy Shih estimates that, because the United States has offshored much of its production capacity in this industry, U.S. firms capture only about 24 percent of the profits from manufacturing the Kindle.[42]

In short, the interdependence between production and innovation is apparent in many industries, and policymakers ignore this fact at the peril of eroding America's competitive edge in both current and future industries and in services as well as manufacturing. Because of the strong links between manufacturing capacity and high-tech innovation, even those who believe much of America's economic future rests in the service sector should not support offshoring production.

Some argue that increasing the rate of innovation in the United States could be counterproductive to manufacturing employment.[43] If technological progress means that fewer workers can produce the same amount of goods, then, the argument goes, that progress must reduce the number of manufacturing jobs. Both economic theory and evidence, however, contradict this argument. In fact, the evidence suggests just the opposite: that productivity growth leads to job gains rather than job losses in manufacturing. (See Box 2.)

Box 2. Manufacturing Job Losses Are Not the Result of Rapid Productivity Growth

Some argue that strong productivity growth has caused much of America's manufacturing job loss, especially in the last decade.[44] This theory, which contends that technology is replacing workers, stems from the observation that apparent productivity gains have coincided with manufacturing job loss in the 1990's and 2000's. Yet there is no economic reason why increased productivity must lead to job loss. Even though a productivity increase means that fewer workers are needed to produce a given quantity of output, the productivity increase also allows product prices to be lower, increasing the size of the product market. The bigger market means that firms will need to hire more workers. The additional hiring needed to produce for a bigger product market usually offsets the initial labor-saving impact of the productivity increase. Therefore, the overall impact of a productivity increase is usually to expand employment rather than reduce it.

Recent trends in manufacturing productivity and employment support this theoretical explanation. Comparing job losses to productivity gains shows that major losses of manufacturing jobs are very difficult to attribute to productivity gains. Nearly three fourths of the decline in U.S. manufacturing employment occurred between 2000 and 2010. From the 1990s to the first decade of the 21st century, the rate of job loss accelerated more than 1000 percent. This was true

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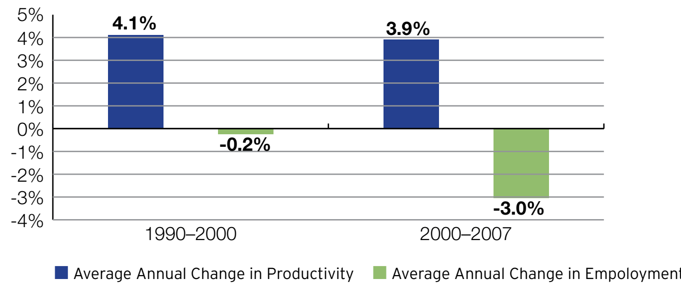
even before the onset of the Great Recession: manufacturing employment shrank by 3.4 million from 2000 to 2007 alone.[45] If productivity gains drove this trend, a sharp rise in the rate of productivity growth would be expected from the 1990s to the 2000-2007 period. Yet as figure 3 shows, the rate of productivity gains did not grow between these two time periods; in fact the rate of growth slowed slightly.

A more detailed examination by economist William Nordhaus shows that within each manufacturing industry, increases in the rate of productivity growth were associated with increases in the rate of job growth (or decreases in the rate of job loss) during the 1948-2003 time period. Replicating Nordhaus' study with Bureau of Labor Statistics data for the years from 2001 through 2009 shows that the positive effect of productivity growth on manufacturing job growth was weaker than before. However, there is no evidence that productivity increases were significantly correlated with job loss.[46]

Figure 3. Productivity and Employment Change in U.S. Manufacturing, 1990-2000 and 2000-2007



Source: Authors' analysis of Bureau of Labor Statistics Major Sector Productivity and Costs data (productivity) and Current Employment Statistics data (employment).

Countries differ in whether productivity growth in manufacturing coincides with employment growth or decline, and by how much. Canada and Italy show modest rates of annual manufacturing productivity growth during the 1990's (3.6 percent and 2.6 percent, respectively), while the two countries grew their manufacturing employment by 9.4 percent and 4.0 percent during the same decade. Meanwhile the Netherlands and Japan had annual productivity gains within the same range (averaging 3.5 percent and 3.4 percent, respectively), while their manufacturing employment shrank by 4.1 percent and 12.2 percent in the 1990's.[47]

Our finding that even in recent years there is no relationship between U.S. productivity growth and manufacturing job loss is remarkable because official productivity statistics overstate recent productivity growth in manufacturing, as explained in Box 1. Overstated recent productivity growth, combined with the huge recent losses of manufacturing jobs, would be expected to lead analysts to find that productivity growth is associated with job loss in manufacturing. Yet, even studies that use the official data do not find that productivity growth causes manufacturing job loss.

The argument that productivity growth leads to reduced manufacturing employment rests on two assumptions, both of which are faulty. First, it assumes that the quantity of manufactured goods demanded by consumers does not rise much when prices fall relative to incomes. This is simply not true for the world taken as a whole. Second, it assumes that workers whose skills are currently low cannot be taught to use information technology to make them more productive. Again, this assumption is false. A 2011 Case Western Reserve University survey of automotive suppliers asked plant managers about their use of information technology.[48] It found that 84 percent of respondents had information technology on the shop floor and that only 8 percent of those respondents agreed with the statement, "We have found that use of Information Technology (IT) reduces the need for shop-floor workers to have analytical skill."

In short, the effects of productivity on American manufacturing employment likely are still positive. Although domestic manufacturing employment has decreased in recent decades, Nordhaus' work suggests that employment loss would have been worse were it not for continued productivity gains. Much of what is measured as productivity growth is actually increased offshoring, or quality improvement in computers. Thus, correctly measured, productivity gains in most of manufacturing have in fact been relatively modest. If anything, it is our lack of sufficient productivity growth—not the growth that did occur—that helps explain recent U.S. manufacturing job loss. Because manufacturing competition is global, individual countries can grow their share of the total work even when aggregate demand does not grow, or as new competitors emerge.[49] Productivity is an important front on which this competition occurs. If the United States had experienced stronger productivity growth in sectors besides computers and electronics in the past decade, the U.S. manufacturing sector likely would have hemorrhaged less work.

3. Manufacturing is Essential for Reducing the Nation's Trade Deficit

The nation has had a trade deficit in every year since 1976 but that deficit has been extraordinarily high during the early 21st century. It has been at least 2.7 percent of GDP in every year since 1999. (Before 1999, the trade deficit reached 2.7 percent or more only during 1984-87.) Before the Great Recession began in 2007, the trade deficit had been increasing steadily since the late 1990s, reaching a record high of 5.6 percent of GDP before falling during the recession. However, it began rising again after the recession, increasing from 2.7 percent of GDP in 2009 to 3.9 percent in the second quarter of 2011—a percentage that was still higher than in any year after 1999.[50]

The trade deficit matters for two reasons. First, it reduces national income and employment in both the short term and the long term. In the short term a large trade deficit makes the still sluggish economic recovery even more so, because imports create fewer jobs in the United States than do goods or services provided domestically. In the long term the trade deficit can gradually erode the ability of the United States to have a dynamic, innovation-driven economy because Americans can lose the ability to innovate if they buy innovative products from abroad rather than make them at home. The trade deficit also matters because it adds to the nation's indebtedness to other nations. A trade deficit has to be paid for by borrowing from abroad. That debt must eventually be repaid out of future U.S. income. A small trade deficit is easy for the nation to handle if long-term economic growth is modest or better. That was the situation from 1976 through 1998, when the trade deficit averaged only 1.5 percent of GDP and inflation-adjusted GDP grew at a 3 percent annual rate. However, a persistent, large trade deficit could cause the nation's future standard of living to fall below today's level. That is the danger the nation faces today, with a trade deficit of more than 3 percent of GDP and inflation-adjusted GDP growth at only 1.6 percent from the second quarter of 2010 through the second quarter of 2011.[51]

Trade and currency policies are major causes of the huge trade deficit. From the late 1990s until the beginning of the Great Recession, the value of the dollar was high by historical standards.[52] Although the value of the Chinese yuan has recently begun to rise slightly—leading some manufacturers to bring work back to the United States from China, as described in Box 3—China and some other Asian countries continue to keep the value of their currencies artificially low.[53] The federal government has done little to rectify these currency imbalances. In addition, most U.S. trade agreements do not contain meaningful, enforceable labor and environmental standards, so lax regulations and artificially low wages make less-developed countries attractive to manufacturers seeking low costs. After China entered the World Trade Organization in 2001, the U.S. trade deficit with China began growing by $30 billion annually instead of the $9 billion at which it had been growing up to that point. This event alone is estimated to have eliminated about 1.76 million U.S. jobs (not all of them manufacturing) from 2001 to 2006.[54]

The United States has long had a trade deficit in manufacturing. (There is also a trade deficit in agriculture and natural resources, which is driven largely by oil imports. The nation has a small trade surplus in services.) Like the overall trade deficit, the manufacturing trade deficit rose during the past decade up through 2006, then fell during the recession years 2007-2009, and then rose again in 2010. Manufacturing's trade deficit for the first two quarters of 2011 totaled $220.6 billion, compared to $189.5 billion for the same quarters of 2010. This suggests that the United States is on track to post an even larger trade deficit in manufacturing in 2011. Because manufacturing contributes to the overall trade deficit, strengthening U.S. manufacturing can help reduce the deficit. It can do this by reducing imports as well as by increasing exports. Manufacturing is particularly important for reducing the overall trade deficit because it accounts for about 65 percent of all U.S. trade (exports and imports combined).[55]

Although it is theoretically possible for the nation to eliminate its trade deficit by increasing exports and reducing imports of services, agricultural products, and natural resources alone, the task would be much easier to accomplish if manufacturing were also included. The nation could eliminate its trade deficit by 2019 by increasing exports of services alone only if service exports increased at an average rate of at least 13.5 percent per year between 2010 and 2019, 5.6 percentage points faster than their 2001–2010 annual average growth rate of 7.9 percent. Alternatively, the nation could eliminate the trade deficit by 2019 by increasing exports of agricultural products and natural resources alone only if those exports increased at an average rate of at least 23.5 percent per year between 2010 and 2019, 12.5 percentage points faster than their 2001-2010 growth rate . In contrast, it would be somewhat easier, although still difficult, to eliminate the trade deficit with manufacturing exports alone. That would require manufacturing exports to grow at an annual rate of at least 9.3 percent, 3.3 percentage points above their 2001-2010 annual average growth rate of 6.0 percent.[56]

Moreover, it is likely to be less costly for the nation to increase exports of manufactured goods than to increase exports of services, agricultural products, or natural resources. Substantially improving the trade balance in agriculture and natural resources is difficult in the short term because it requires a large reduction in oil imports or a large increase in natural gas exports. Reducing the number of barrels of oil imported is an energy security and environmental imperative and is likely to occur gradually if the price of oil continues to rise as it has over the last decade. However, a substantial reduction in the nation's total bill for imported oil is not likely in the next few years, even under the most favorable policy assumptions, because it will take time for U.S. oil consumption to respond fully to a price increase and because a reduction in quantity imported is likely to be offset by an increase in the price per barrel. The exploitation of new sources of natural gas in the United States could lead to a boom in gas exports but this, too, will probably take a number of years. Such shale gas could eventually affect oil imports, but only slightly. Natural gas may be a good candidate to displace the 1 percent of U.S. oil consumption used for electricity generation or the 6 percent used for residential and commercial purposes, but is unlikely to displace the remaining 93 percent of U.S. oil consumption devoted to transportation and industrial uses.[57] As discussed below, a revived U.S. manufacturing sector could contribute substantially to reducing oil imports by increasing renewable energy capacity and promoting efficiency in energy use.

For the growth of service exports, the picture is more mixed. In general, the presence of substantial restrictions on service imports in the large, rapidly growing, less-developed economies is likely to slow the growth of American service exports.[58] On the other hand, a worldwide infrastructure boom over the next 25 years could lead to a boom in exports of engineering services.[59] The erosion of U.S. technological superiority could limit the future growth of royalties and license fees, which accounted for almost half of the growth in the services trade surplus between 2000 and 2010.[60] (Because industrial-process patents constitute the largest share of royalty- and license-related exports ($40 billion out of $94 billion in U.S. royalty and license-fee exports in 2008), the nation's ability to increase those exports depends on future U.S. technological innovation.[61]) Although the United States has more foreign students than any other advanced country, the growth of U.S. educational services exports is likely to slow over the next decade as the number of college-age people outside the United States falls.[62] Travel and passenger fares, service export categories that grew rapidly during the past decade, could easily grow even more rapidly if the nation eased post-September 11 travel restrictions. However, rising oil prices and a slowdown in economic growth in the rest of the world could slow the growth of foreign tourism.

In contrast, both the economics of exporting and existing federal manufacturing policy are favorable to an increase in the growth rate of manufacturing exports. Today, manufacturers are more likely to export than service-providing companies.[63] Moreover, firms that export today are more likely to export again than are those that never exported or exported a long time ago.[64] Thus, manufacturers are more likely to increase their exports than are service firms. Furthermore, high-productivity companies are more likely to export than are low-productivity ones, and there is already a successful, low-cost federal program, the Manufacturing Extension Partnership Program, that assists manufacturers in becoming more productive.[65] No similar program exists for service firms.

Because the U.S. trade balance can be improved by reducing imports as well as by increasing exports, the return to the United States of some previously offshored production (sometimes called "re-shoring") is another means of reducing the trade deficit. Here, too, manufacturing has the advantage, primarily because recent developments in China, a site of a great deal of offshored manufacturing but little offshored service work, are becoming more favorable to the return of U.S. production. (See Box 3.)

Box 3. The "Re-Shoring" of Manufacturing

In the past two to three years a number of companies have chosen to bring some previously offshored work back to the United States, leading many to wonder whether the pace of offshoring is slowing or even beginning to reverse.[66] Recent case studies show that the reasons for "re-shoring" work include rising oil prices, longer shipping times, rising wages in coastal Chinese cities, intellectual property leakage, the desire to create innovation hubs, and a fuller appreciation, based on years of experience, of the downsides of offshoring. American firms are now more likely to appreciate "hidden costs" of production abroad, such as administrative costs, legal costs, risks and complexities. Even General Electric (sometimes referred to as the "godfather of offshoring") is re-assessing its calculations, reflected in a GE representative's recent statement that what used to be "a 30 percent Chinese cost advantage likely has tilted to roughly a 6 percent U.S. edge when figuring lower inventory expenses and fewer delivery snafus."[67]

Consider some of the hidden costs of having suppliers far away. First, top management is distracted. Setting up a supply chain in China and learning to communicate with suppliers requires many long trips and much time, time that could have been spent on introducing new products or processes at home. Second, there are increased coordination and "handoff costs" between U.S. and foreign operations. More difficult communication among product design, engineering, and production hinders serendipitous discovery of new products and processes. Quality problems may be harder to solve because of geographic and cultural distance. Time to market may increase. Third, there is increased risk from a long supply chain, especially with just-in-time inventory policies. Shipping prices and delivery times can vary enormously. For example, reduced production during the economic crisis in spring 2009 caused the shipping industry to take ships out of service, and the container-manufacturing industry to freeze the production of many shipping containers.[68] Since then, demand for the trans-Pacific transport of goods has rebounded, but the shipping infrastructure has not. Moreover, many ships have switched to "slow steaming" practices, which save fuel but increase shipping time. The result is a dramatic increase in trans-Pacific shipping time and cost, and a reduction in reliability.

Another factor that has caused U.S. manufacturers to consider "re-shoring" is the convergence of wages between the United States and China. Chinese manufacturing wages have risen in recent years (a development that has been slightly magnified by a small rise in the value of the Chinese yuan), while U.S. manufacturing wages have declined. Manufacturing wages in China rose by an average of 19 percent per year between 2005 and 2010 and a Boston Consulting Group report projects that they will continue to increase by 17 percent annually until 2015.[69] Of equal importance, productivity in Chinese manufacturing appears to be growing only about half as quickly, so unit labor costs in Chinese manufacturing are rising. Meanwhile, the inflation-adjusted hourly wage in all U.S. manufacturing peaked at $10.82 per hour (in 1982-84 dollars) in March and April 2009 and generally fell thereafter, reaching $10.47 per hour in September 2011.[70]

All told, whereas Chinese labor costs were only 3 percent of those of U.S. labor in 2000, that figure had risen to 9 percent by 2010 and is projected to reach 17 percent by 2015. While 17 percent may still seem like significantly cheaper labor, labor costs usually constitute less than a quarter of a product's cost, and as little as 7 percent for some products.[71] Thus, reducing wages contributes only modestly to reducing total manufacturing costs, and the wage gap between the United States and China must be quite extreme to offset the added costs of a trans-Pacific supply chain. Moreover, Chinese manufacturing productivity was still only 29 percent of U.S. productivity in 2010, meaning that firms must hire more Chinese workers to produce the same amount.[72] In short, rising Chinese wages and stagnant (and in many cases decreasing) U.S. wages have favored the location of manufacturing in the United States. However, this wage convergence is a mixed blessing; this sort of "race to the bottom" is problematic if one takes the view that a key purpose of an economy is to provide family-supporting jobs.

These considerations likely explain why 61 percent of 287 manufacturing firms in a recent survey reported that they are considering "shifting their manufacturing operations closer to customers."[73] Firms were mostly likely to express concerns about delivery time and product quality as the major factors driving plans to shorten supply chains. Relocating production nearer to consumers does not necessarily mean moving it to North America, especially as demand for cars and other manufactured goods grows sharply in countries such as China and Brazil. Yet surveyed firms with $250 million to $5 billion in annual sales report that demand for their products exceeds supply by a greater margin in the United States and Canada than in any other region of the world. These large manufacturing firms report that they plan to reduce this disparity between North American production supply and demand in the next three years. Anecdotal evidence also suggests that the offshoring of manufacturing is slowing or reversing. A number of companies, including NCR, Coleman, Ford, Sleek Audio, Peerless Industries, and Outdoor Greatroom Company, have moved or plan to move production from other countries, including China, to the United States.[74]

Although the re-shoring of manufacturing is good news for the United States, it is not a smooth or automatic process. An example illustrates why. In 1995, a Florida entrepreneur opened a Florida factory to make shoes; after

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trying valiantly to keep it open, he closed it in 2008. Labor costs in his factory were competitive; the problem was that the industry's supply chain had long moved far away. He had to fly in technicians to repair machines, and could not find domestic supplies of specialized inputs like eyelets and shoelaces. Since his strategy relied on customization, he was particularly hurt by the lack of variety available in these components. Because customers were few, suppliers could not afford to incur the fixed costs for more than a few varieties.[75]

Thus, optimism that manufacturing will return automatically once exchange rates are allowed to balance imports and exports is misguided. Exchange rates do affect exports—and, therefore, U.S. employment—in manufacturing. However, once the dense network of suppliers disappears, the fall in the dollar required to justify reinvestment is much greater than that necessary to expand existing operations—meaning an even greater fall in the standard of living. Policymakers may not be so concerned about a failure to re-establish a low-technology industry like shoes, but the frayed production networks in industries such as tooling and electronics should be cause for great concern.[76]

Different manufacturing industries contribute differently to the nation's trade balance. Although the nation runs a large trade deficit in manufactured goods as a whole, about 64 percent of that deficit comes from just three industries: computers and electronics (which accounts for 28 percent of the manufacturing trade deficit), apparel (17 percent), and transportation equipment (12 percent).[77] In contrast, the United States runs trade surpluses in six major manufacturing industries: machinery, chemicals (but, notably, not pharmaceuticals, which are included in chemicals), food, paper, textile mills, and printing (Appendix table 9).

An industry's current trade balance, however, says little about the industry's contribution to improving or worsening that balance. The change in the trade balance between 2001 and 2010, shown in Appendix table 9, provides this information for manufacturing industries during the last decade. All the industries that had trade surpluses in 2010 also improved their trade balances between 2001 and 2010.[78] The trade balance in computers and electronics, on the other hand, worsened by much more than that of any other manufacturing industry. That industry, which was well known for offshoring during the last decade, accounted for 95 percent of the deterioration in the nation's manufacturing trade balance over the decade.[79]

It is of particular concern that trade balances in industries likely to be heavily involved in reducing use of carbon-based energy (computers, electrical equipment, plastic and rubber parts, and fabricated metal products) are all deteriorating. It is quite likely that energy prices will rise dramatically in coming decades, both because of increased demand from developing countries and because of efforts to combat climate change. These rising prices will worsen the trade deficit due to increased prices for imported oil. Innovative manufacturing could significantly cushion this blow in a variety of ways. First, renewable energy systems (such as wind, solar, or geothermal) require significant new equipment. Second, efforts to increase the efficiency of energy use also require manufactured inputs, such as turbines for co-generation, insulation for buildings, and lighter-weight materials for cars. Importing these manufactured products adds even more to the trade deficit.

4. Manufacturing makes a disproportionately large contribution to environmental sustainability

Manufacturing makes a disproportionately large contribution to America's "clean economy"—the production of goods or services with an environmental benefit. According to a recent Brookings estimate, the clean economy is nearly three times as manufacturing-dependent as the overall economy. Of the clean economy's 2.7 million jobs, 26 percent are in manufacturing, compared to 9 percent of U.S. jobs overall. This large role for manufacturing helps explain why the average clean economy job contributed $20,129 in 2009 exports, achieving twice the export-intensity of the average U.S. job.[80]

A number of specific technologies and products that are critical to the clean economy are highly manufacturing-intensive. At least 90 percent of all jobs in electric vehicle technologies, water-efficient products, green chemical products, energy-efficient appliances, sustainable forestry products, lighting, recycled-content products, and energy-saving consumer products are in manufacturing. More than two-thirds of all jobs in solar photovoltaic, solar thermal, and wind energy are manufacturing jobs.[81] In addition to energy-efficient appliances, energy-saving insulation and heating, ventilation, and air conditioning (HVAC) systems are all manufactured goods that are used heavily in retrofitting buildings to be more energy-efficient.

These manufacturing-intensive technologies and products have the potential to grow, creating more high-wage jobs than the technologies and products they would replace and making manufacturing more important to the U.S. economy as a whole. For example, For example, renewable energy has the potential to be both affordable and an engine of growth in good jobs because the basic input (sun or wind) is free.[82] In contrast, much of the cost of oil or coal consists of payments to the owners of those scarce resources. Thus, it is possible to pay a great deal in wages to workers to turn the sun or wind into usable power while still keeping the end-user price at levels comparable to those of coal or oil (especially if the environmental costs of these dirty technologies are factored in). A University of California, Berkeley, review finds that solar energy supports seven to 11 jobs per megawatt-hour produced (MWa) while coal supports only one job per MWa, and natural gas less than one job.[83] A program that created enough renewable capacity to meet 10 percent of U.S. electricity demand would not only reduce dependence on foreign oil and cut carbon emissions—it would also employ about 340,000 people for a year in each of five years. It would cost about $35 billion per year for each of those five years. Creating these jobs would raise average wages (these occupations currently pay 12.5 percent more than the economy-wide average), and would reduce unemployment as well.[84]

Similarly, building retrofits have growth potential and, with them, the manufacturing of energy-saving insulation, appliances, and HVAC systems. If the nation retrofitted all eligible buildings over ten years, it would create about 215,000 direct jobs (127,000 direct jobs in manufacturing, and many more indirect jobs from production inputs) lasting through that decade, reduce carbon emissions, and pay for itself in reduced energy use (even at current artificially low prices) by the time these retrofits were completed.[85]

A strong domestic manufacturing sector provides the United States with the workforce skills, engineering talent, and innovative capacity to meet the challenges of reducing energy consumption and producing clean energy.[86] If the United States manufactures most of its own clean energy infrastructure, addressing climate change will create American jobs and profits instead of future trade deficits. As the costs of fossil fuel technologies gradually rise, the capabilities to design and produce low-carbon products will become more important to the nation's standard of living.

B. Which Manufacturing Matters?

Crafting effective manufacturing policy at any level of government will require acute appreciation of the vast differences among manufacturing industries and firms. Policy that aims to strengthen all manufacturing industries, and all types of firms within those industries, will be misguided not only because it will be ineffective, but also because strengthening all parts of manufacturing should not be a policy goal. The following sections will discuss why some manufacturing industries hold more potential for growth and why production strategies that by only some firms have currently adopted promise better long-term outcomes for business and workers. Federal policy should be mindful of such heterogeneity, helping to re-allocate workers towards high-growth industries, addressing market failures that allow perennially low-productivity firms to compete better, and helping those low-productivity firms increase their productivity.

1. The United States is Most Likely to Retain or Grow Jobs in High-Wage Manufacturing Industries and Those with High Shipping Costs, but Modest Opportunities Also Exist in Middle-Wage Durable Goods

The previous sections of this report examined the extent to which different manufacturing industries serve critical national needs in the areas of wages, innovation and trade. A national manufacturing policy, however, also requires an assessment of which industries the nation is most likely to retain or grow. If the industries that best serve an important national need are also hopelessly uncompetitive, then a policy to promote them may not be wise.

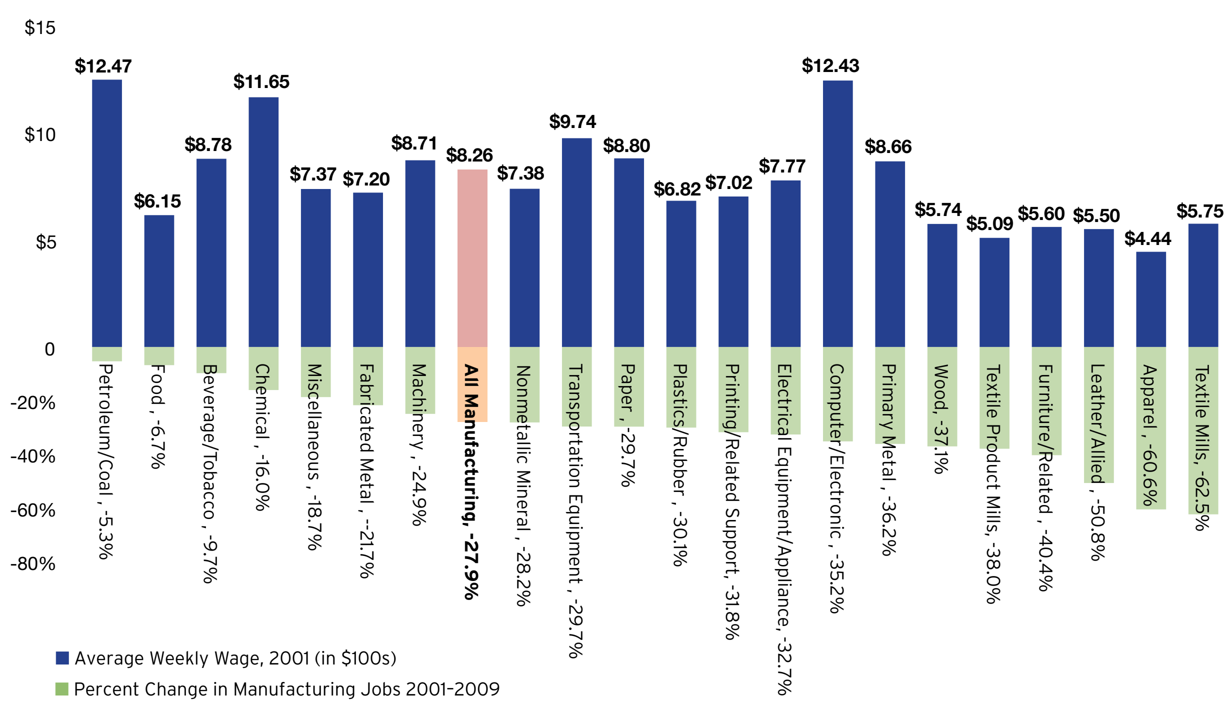
This section of the report assesses the extent of future job growth or loss in manufacturing industries in two steps. First, it examines job change in manufacturing industries from 2001 through 2009, a period that includes a full economic upturn and downturn and that precedes the recent growth of manufacturing jobs. Then it looks at what has happened during the last two years of manufacturing job growth. Because it is possible that the trends of the more recent period will continue but it is difficult to be confident about how long they will persist or how strong they will be, the 2001–2009 trends are best considered as baselines that the more recent trends could modify.

All major manufacturing industries lost jobs between 2001 and 2009. However, the smallest losses were typically in two kinds of industries: high-wage industries (which are also high-productivity industries due to their intensive use of capital and/or skilled workers) and industries whose products are heavy in relation to their value, meaning that transportation costs are an important consideration in the location of factories.[87] Figure 4 shows the 2001-2009 percentage job loss and the 2001 average weekly wage for each major manufacturing industry, while Figure 5 shows the job loss and value of shipments per ton for each industry.

The industries that lost the highest percentages of jobs were textile mills, apparel, leather and allied products, and furniture. These were also among the lowest-wage industries and all had value per ton well above the all-manufacturing average (meaning that their products were relatively light-weight in relation to their value, so that shipping costs were relatively low). The industries that lost the lowest percentages of their jobs were petroleum and coal products, food, beverage and tobacco products, and chemicals. Petroleum and coal products and chemicals were among the three highest-wage industries, and petroleum and coal products had very low value per ton. Both food and beverage and tobacco products had relatively low value per ton, and beverages and tobacco products paid wages somewhat above the manufacturing average. Computers and electronics, the second highest-wage industry, also had the highest value per ton (indicating low shipping costs) and had relatively large job losses.

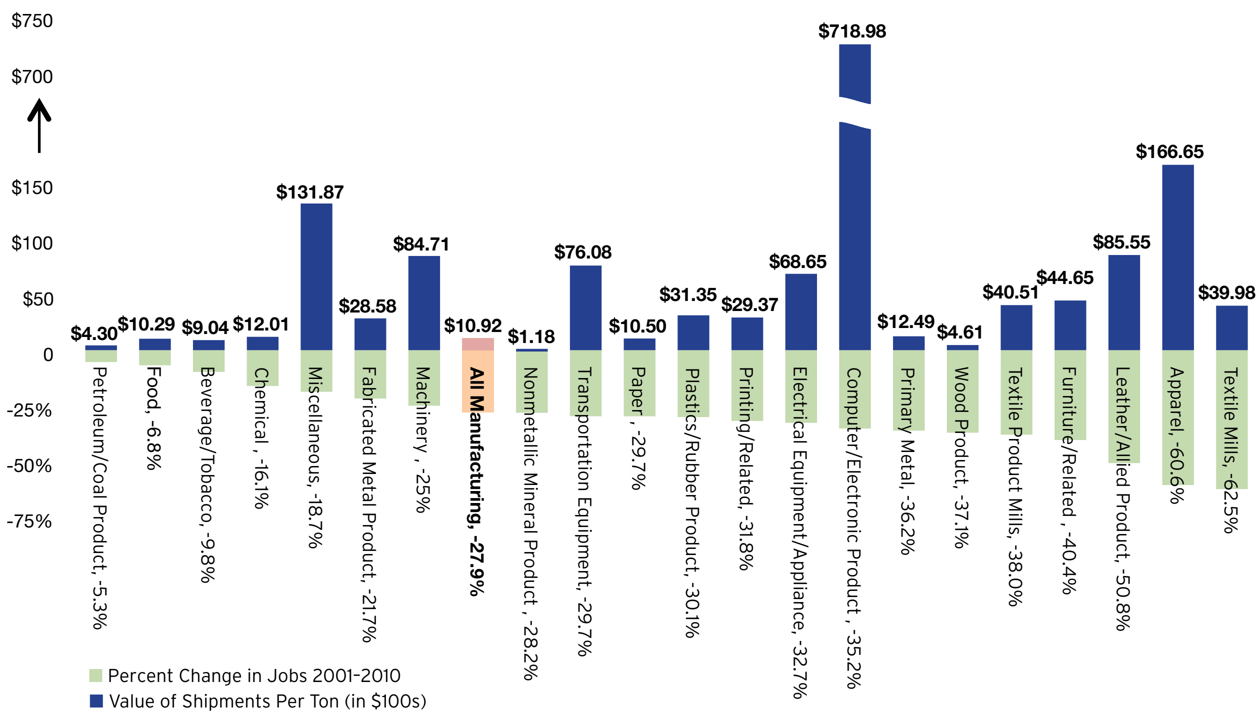
An examination of more detailed industries underscores these points. Appendix table 10 shows that there were 45 detailed manufacturing industries in which the United States actually gained jobs between 2001 and 2009.[88] Twenty-six of these industries had wages above the manufacturing average

Figure 4. 2001-2009 Job Loss and 2001 Average Weekly Wage



Source: Source: Authors' analysis of Bureau of Labor Statistics Quarterly Census of Employment and Wages data.

Figure 5. 2001-2009 Job Loss and 2007 Value of Shipments Per Ton in Manufacturing Industries



Note Value per ton is based on shipments that originate and terminate in the United States, regardless of their ultimate origin or destination.

Source: Authors' analysis of Bureau of Labor Statistics Quarterly Census of Employment and Wages and 2007 Census Bureau Commodity Flow Survey data.

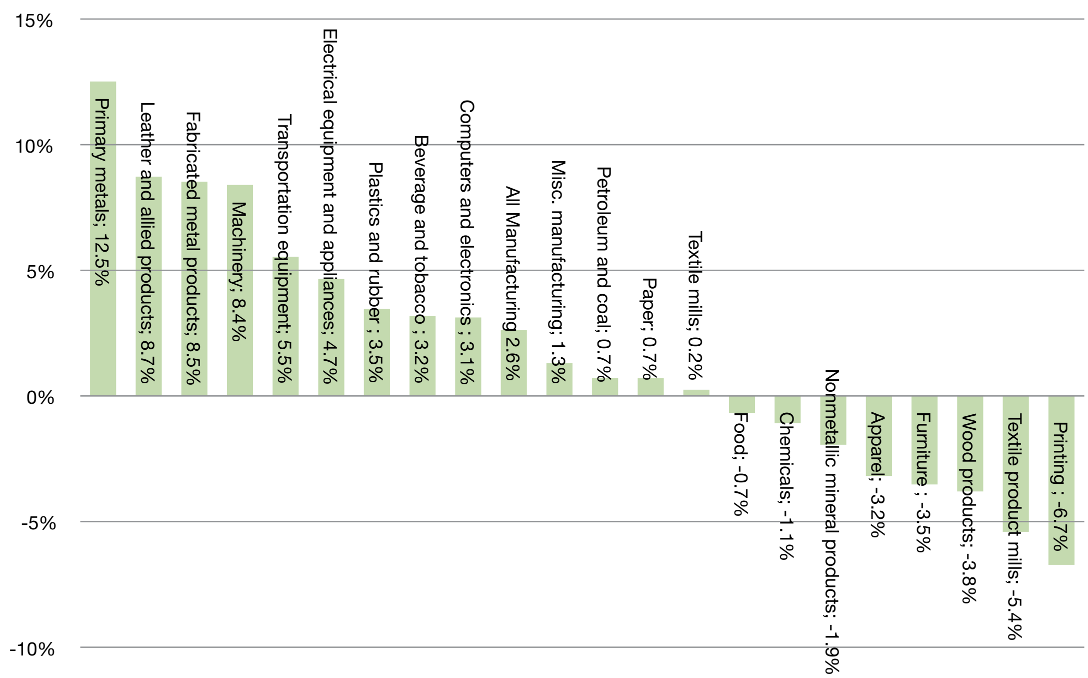
in 2001. Among these were some very high-wage industries, such as petroleum refineries, search/detection/navigational instruments, guided missiles and space vehicles, and electromedical apparatus. However, the job-gaining industries also included several kinds of low-wage food manufacturing and other low-wage industries such as cut stone and stone products. Although there are no data on value per ton for such detailed industries, the job-gaining industries seem to be ones with high shipping costs; many are in major industry categories with low value per ton.

Since the end of 2009, the situation has been somewhat different. Durable goods industries, except for furniture, nonmetallic mineral products, and wood products, gained jobs between December 2009 and September 2011. Among nondurable goods industries, beverage and tobacco products, textile mills, leather, paper, petroleum and coal products, and plastics and rubber products also gained jobs, while food, textile product mills, apparel, printing, chemicals, and nonmetallic mineral products all lost jobs (figure 6).

The greatest percentage job gains came in primary metals, leather, fabricated metal products, and machinery, while somewhat smaller gains occurred in transportation equipment and electrical equipment/appliances. With the exception of the very low-wage leather industry, these are middle-wage durable goods industries with relatively low shipping costs. The greatest percentage job losses occurred in printing and textile product mills—both low- to moderate-wage nondurable goods industries with relatively low shipping costs. The relationship of job change to wage levels was much weaker during the last two years than earlier in the century, and there was virtually no relationship between shipping costs and recent job change.

Overall, the United States remains most likely to retain or grow employment in high-wage manufacturing industries and those with high shipping costs. However, to the extent that the trends of the last year and a half continue, there will also be modest opportunities to retain and grow jobs in middle-wage durable goods industries including the auto industry, and in the high-wage computers and

Figure 6. Percent Change Jobs in Manufacturing Industries, Dec. 2009–Sep. 2011



Source: Authors' analysis of Bureau of Labor Statistics Current Employment Statistics data.

electronics industry.[89] Absent a dramatic policy shift, most clothing-related industries, printing, and furniture will probably continue to lose jobs.

The durable goods job gains of the past year and a half may turn out to be nothing more than a partial recovery of jobs lost during the recent recession and, like similar recoveries following the recessions of the 1980s and 1990s, only a brief interruption in a three decade-long downward trend. Support for that view comes from the fact that the growth rate of durable goods jobs in the 21 months since they reached their post-recession low was slower after the Great Recession than after the recessions of the early 1980s and early 1990s.[90] However, the driving forces behind the recent uptick in durable manufacturing jobs—rising wages in China, modestly falling wages in U.S. manufacturing, a small increase in the value of the Chinese yuan since mid-2010, and a reassessment by many manufacturers of the true costs and benefits of offshoring—are not likely to be reversed for at least the next few years, although eventual increases in U.S. manufacturing wages are both possible and desirable.[91]

As long as these developments are not reversed, the recent small gains of durable manufacturing jobs are likely to continue. Yet there is no way to be confident that recent trends will strengthen, so the nation can expect only modest gains in middle-wage durable manufacturing jobs unless there are major changes in U.S. manufacturing policy. With policy changes, new forces, such as stronger productivity growth, could supplement rising Chinese wages, currency revaluation, and manufacturers' reassessment of offshoring to promote manufacturing job gains in the United States. Better workforce skills, and the higher wages they support, could become sources of long-term competitiveness and growth in U.S. manufacturing, replacing wage cuts as a force for manufacturing job gains.

This analysis of recent employment trends shows that the best opportunities for manufacturing job retention and growth are in industries that do well in wages, innovation, and trade, but there are also important exceptions. (See Appendix tables 2-9.) Among the highest-wage industries, job retention and growth seem most likely in petroleum and coal products, tobacco products, and chemicals—a category that includes pharmaceuticals. Computers and electronics and aerospace, after large employment losses, have also experienced modest employment growth in recent months. Food manufacturing, although generally a lower-wage industry, has strong growth potential as well. Among innovative industries, there is strong growth potential in chemicals (including pharmaceuticals), which rank highly on several dimensions of innovation. Computers and electronics and a number of durable goods industries that excel in at least one type of innovation (e.g., motor vehicles and parts, aerospace, and machinery) have more modest growth potential. For the trade balance, the picture is less clear, but the industries whose trade balances improved the most during the last decade offer strong or modest growth opportunities. Recent trends suggest that the computer and electronics industry, whose trade deficit ballooned in the early years of the century, may grow. More U.S. jobs in this industry are likely to mean an improved trade balance, as previously offshored work returns to the United States, but it is difficult to say how large this improvement will be.

In addition, the United States has opportunities to increase employment in the manufacturing of goods that improve energy efficiency and of goods used to produce and store renewable energy (e.g., solar panels, wind turbines, and advanced batteries).[92] These opportunities, which are not yet reflected even in recent manufacturing employment data, come from likely changes in markets and potential changes in public policy. Shipping costs are likely to rise for all kinds of manufactured goods because demand pressure from China and India will cause an increase in the price of oil. If the United States moves to price carbon emissions, then that will further increase shipping costs.[93] In addition, if U.S. policy strongly supports the production of renewable energy, then there will be more jobs in renewable energy manufacturing, a few of which will come at the expense of existing jobs in petroleum and coal product manufacturing.[94] However, if the United States responds to rising oil prices and global climate change largely through policies that support existing technologies (e.g., natural gas for electricity generation and better fuel economy for gasoline-powered and hybrid cars), then job growth could occur in manufacturing related to those technologies. Of course, none of this will happen if the United States does not adopt policies to respond to climate change, if oil price increases are not rapid enough to result in changes in the kinds of manufactured goods demanded by U.S. consumers, or if imports satisfy changes in consumer demand.

In summary, the findings of this section show that four industries that contribute especially well to all four of the critical national goals that manufacturing serves (high wages, innovation, a reduced trade deficit, and an improved the natural environment) are also likely to retain or expand employment in the future. Those industries are computers and electronics, chemicals (including pharmaceuticals), transportation equipment (including aerospace and motor vehicles and parts), and machinery. Each of these industries pays high wages, ranks highly on more than one measure of innovation, had a shrinking trade deficit or growing trade surplus during the last decade or the prospect of one in the near future, and is either environmentally benign or has the potential to contribute strongly to a better natural environment. Each of these industries has also gained jobs over the last two years.[95]

2. There Are Large Differences in Performance within Industries

The previous discussion emphasized differences among manufacturing industries. However, these differences are not the only ones that matter for manufacturing policy. Firms differ at least as much within industries as between them. Therefore, policies to promote manufacturing should be firm-based as well as industry-based, aiming to help improve the performance of firms in every industry. Conversely, policies should not aim to save all jobs in an industry, but rather focus on promoting practices that generate spillover benefits to communities and workers.

Manufacturing firms within the same industry differ dramatically in wages, innovation, and exporting. A recent Case Western Reserve University survey finds significant variation in wages even within narrow industries.[96] For example, the survey finds that high-wage firms in automotive stamping pay production workers an average of $17 per hour, compared to $13 per hour for middle-wage firms and $10 per hour for low-wage firms.[97]

Within most manufacturing industries, a substantial percentage (between one-fifth and three-fifths) of U.S. companies introduce a new or significantly improved product over a three-year period, while a substantial percentage did not do so; there was also substantial intra-industry variation in the introduction of new or substantially improved production processes. (See Appendix table 4.) Exporting also varies substantially within as well as between manufacturing industries.[98]

Manufacturers within the same industry also differ greatly in their productivity levels. An analysis of the 1977 Census of Manufactures showed that within the average manufacturing industry the productivity of high-productivity plants was about four times that of low-productivity plants.[99] Within such core manufacturing industries as electrical appliances, metal-forming, and plastics processing, the one-third of firms with the lowest productivity (value added per full-time equivalent employee) have productivity of less than $60,000, while the one-third with the highest productivity have median productivity of nearly $120,000.[100] Even within very narrowly defined manufacturing industries, plants differ substantially in productivity. For example, a 2010 survey of manufacturers conducted by the Michigan Manufacturing Technology Center found that productivity in the highest-productivity metal heat treating plant in the survey was 10.4 times that in the lowest-productivity plant. This ratio was 5.2 in printed circuit assembly manufacturing, 4.7 in industrial mold manufacturing, and 1.5 in metal stamping.[101]

Although these differences between firms in the same industry are not inherently bad, extreme variation within an industry can cause long-term problems for both firms and policymakers. When some firms in an industry survive based on perennial cost-cutting, other firms wishing to make long-term investments with high returns can find it difficult to compete in the short term. This can create a race to the bottom not only for wages but other types of investment as well, preventing the whole industry from properly harnessing technological advances. Such variation can also make it more difficult to create policies that promote an entire industry rather than just part of it.

Firms with differential productivity survive in part because they have different "production recipes." In the "high-road" recipe, firms harness the knowledge of all their workers to create innovative products and processes; the higher wages paid to these workers are offset by their higher productivity. The high-road recipe is fairly similar across industries: highly productive firms within each industry design more new products, have lower defect rates, and limit employee turnover far more than do their low-productivity rivals. For an example of these different recipes within one narrow industry, see Box 4.

These practices are largely complementary; adopting one practice often increases the productivity impact of other practices. Thus, a firm's product designs will be better if it takes into account suggestions from workers about how to change aspects of the design that frequently lead to defects. These suggestions are likely to be better if workers are more skilled and experienced. Thus, product design, quality circles, and high pay are most effective if adopted together. In contrast, "low-road" firms are much less productive but survive because their wages, management staffs, and investments are all smaller.[102]

These low- productivity firms can remain in business because of three market failures. First, it is difficult for many firms, especially small and medium-sized ones, to make the costly, near-simultaneous investments needed to adopt the high-road strategies described above. Second, different customer firms share the same suppliers. Assemblers would benefit from having suppliers that were more capable of providing high quality or reliable delivery, but because rivals would benefit from investment in suppliers, individual assemblers have insufficient incentive to invest in helping suppliers make such improvements. Finally, workers value high-wage jobs, but firm owners rarely take this benefit to workers into account when making investment decisions. Thus, there are too few high-wage jobs from a social point of view.[104] If public policy does not help firms overcome these market failures, the productivity gap between firms will remain wider than it needs to be, and work will continue to move abroad.[105]

Because there is such wide variation in performance among firms in the same industry, the U.S. economy would benefit if the performance of low-performing firms were improved, or if these firms were replaced by high-performing ones. Manufacturing policy should create incentives for manufacturing firms in all industries to improve. Often such improvement requires coordinated investments in multiple areas, such as equipment, workforce training, and software. Programs that help firms plan and execute such investments will produce benefits for industry, workers, and society. Industry will benefit through better profits and more resilience in the face of economic cycles. Workers will benefit from better skills, higher wages, and more career mobility. Communities and non-manufacturing industries will benefit from the ripple effects of more middle class jobs and higher government revenues.

Box 4. How Performance Varies Among Automotive Stampers

Data from Case Western Reserve University's 2011 survey of automotive suppliers illustrates the wide variation within manufacturing industries. One very narrow industry, automotive stamping, provides an example of the wide diversity of production recipes—business strategies and associated ways of organizing production— adopted by different firms. Automotive stampers, primarily located in NAICS codes 332116 and 336370, use stamping presses produce automotive parts from sheet metal.

As figure 7 shows, this industry (like most industries) is characterized by wide dispersion in productivity. High-productivity firms have productivity that is more than twice that of medium-productivity firms.[103]

Similarly, there is great variation in wages paid to workers in the same occupation. High-wage firms pay 70 percent more than low-wage firms (figure 8).

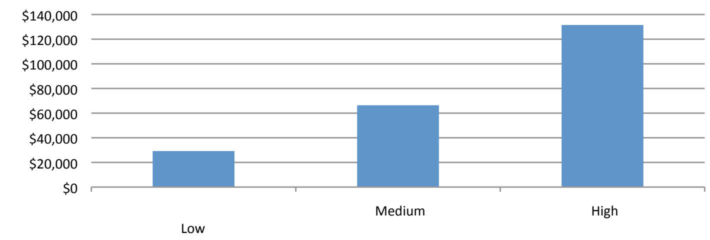
"High-road" firms remain in business while paying far higher wages than their competitors do, because highly skilled workers help firms achieve high rates of innovation, quality, and fast response to unexpected situations. The resulting high productivity allows firms to pay high wages to workers while still making profits that are acceptable to owners. In stamping, as in most manufacturing, direct labor costs are a small portion of total costs (usually far less than 20 percent). Strategies other than minimizing direct labor cost (such as avoiding downtime and introducing innovative products and processes) can thus be key sources of competitive advantage. Shop-floor workers can play an important role in these areas by participating in continuous improvement activities, as discussed below. These activities increase the return to having skilled and motivated workers, so are most effective if accompanied by above-average wages.

Preventive maintenance on equipment and quality circles are two examples of continuous improvement techniques that contribute to higher productivity. Developing schedules for preventive maintenance draws on workers' knowledge about the sources and frequency of failure of different kinds of machines; having a broadly-trained workforce that can do a variety of tasks makes it more likely that a plant can adhere to these schedules. Quality circles are groups of employees from a variety of levels and functions that meet regularly to brainstorm ideas for improvement.

Figure 9 shows that stampers that adopted these techniques dramatically

continued ➤

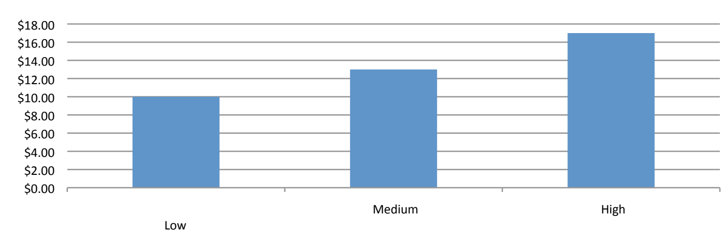
Figure 7. Productivity (Output Per Employee) at Automotive Stampers, 2010



Note: Productivity at each plant is calculated as 2010 sales net of purchased inputs, divided by the number of employees at the plant. Low-productivity firms are those with higher productivity than 10 percent of firms and lower productivity than 90 percent. Medium-productivity firms are more productive than 50 percent of firms and less productive than 50 percent. High-productivity firms are more productive than 90 percent of firms and less productive than 10 percent.

Source: Authors' analysis of unpublished data from Case Western Reserve University survey of automotive suppliers.

Figure 8. Hourly Wages of Production Workers at Automotive Stampers, 2010



Note: Low-wage firms are those with higher semi-skilled worker wages than 10 percent of firms and lower semi-skilled worker wages than 90 percent. Medium-wage firms pay higher semi-skilled worker wages than 50 percent of firms and lower semi-skilled worker wages than 50 percent. High-wage firms pay higher semi-skilled worker wages than 90 percent of firms and lower semi-skilled worker wages than 10 percent.

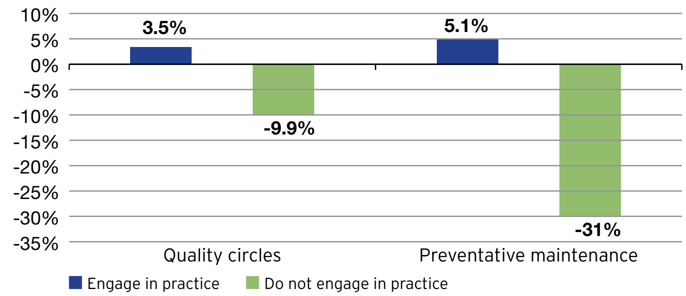
Source: Authors' analysis of unpublished data from Case Western Reserve University survey of automotive suppliers.

continued ➤

increased their sales from 2007 to 2011 compared to stampers that did not. Preventive maintenance insures that machines are ready to be used, while quality circles help firms debug new products quickly. Despite the effectiveness of these practices, in 2011, only 35 percent of stampers surveyed reported using quality circles.

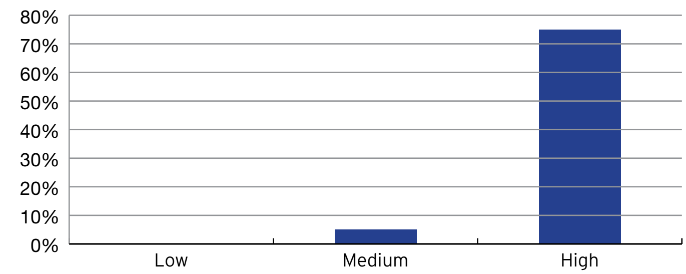
Although most automotive stampers make products according to designs received from their customers, the top 10 percent design products that account for more than 70 percent of their sales (figure 10).

Figure 9. Percent Change in Sales by Automotive Stampers, 2007-2011



Source: Susan Helper and others, "The U.S. Auto Supply Chain at a Crossroads," report prepared for U.S. Department of Labor (Cleveland: Case Western Reserve University, n.d.), figure 22, p. 37, available at http://drivingworkforcechange.org/reports/supplychain.pdf.

Figure 10. Percent of Automotive Stampers' Sales from Products Designed by Firm



Note: Low design-intensity firms derive more sales from products they designed than 10 percent of firms and derive fewer sales from products they designed than 90 percent. Medium design-intensity firms derive more sales from products they designed than 50 percent of firms and fewer sales than 50 percent. High design-intensity firms derive more sales from products they designed than 90 percent of firms and fewer sales than 10 percent.

Source: Source: Authors' analysis of unpublished data from Case Western Reserve University survey of automotive suppliers.

C. A Framework for Manufacturing Policy

The previous sections of this report may leave the impression that the benefits that American manufacturing confers on the nation are in no serious danger. If the kinds of manufacturing firms and industries that are most likely to provide those benefits are also the ones that are most likely to expand or at least retain employment in the United States, then why is there a need for public policy to strengthen manufacturing?

There is a need for manufacturing policy because the levels of performance on which manufacturing excels compared to the rest of the U.S. economy, are very low compared with manufacturing in other economically advanced countries. This section of the report shows how the United States falls short of many other advanced nations on the four critical public needs that manufacturing serves. It then outlines the specific problems that lie at the root of this poor performance and the principles that should guide public policies that aim to solve those problems. The section concludes with an examination of manufacturing policy in Germany, a country in which manufacturing helps enable a large number of middle class jobs, a culture of lifelong learning, a sustained trade surplus, and world-leading performance in producing equipment for renewable energy. Although the specifics of German manufacturing policy cannot be transferred wholesale to the United States, German policy is an important example for U.S. policymakers because it successfully addresses the core manufacturing problems that exist in the United States and does so with policies that adhere to the principles outlined in this report.

1. American Manufacturing's Domestic Strengths Are International Weaknesses

Manufacturing is high-wage, innovative, essential for reducing the trade deficit, and important for environmental sustainability compared with the rest of the U.S. economy. Compared with manufacturing in other high-wage countries, however, it is relatively low-wage, runs a large trade deficit (rather than a surplus, as in many other countries), and is losing its edge in innovation and renewable energy manufacturing.

Manufacturers pay significantly higher wages in many other industrialized nations than they do in the United States. According to the most recent data from the Bureau of Labor Statistics, 12 European countries and Australia have higher average manufacturing wages than the United States. Norway tops the list with an average 2009 wage of $53.89 (in U.S. dollars), which is 60 percent higher than America's average wage of $33.53.[106] In general, U.S. wages are on the lower end of the spectrum for advanced industrial economies (Figure 11). Contrary to some popular arguments, then, it is not high wages that prevent manufacturers from retaining or expanding employment in the United States.[107]

Countries where manufacturing wages are higher than in the United States have not lost manufacturing employment more rapidly than the United States. Despite America's comparatively low manufacturing wages, it lost 28 percent of its manufacturing employment between 2000 and 2010.[108] Among the nine foreign countries for which the Bureau of Labor Statistics tracks manufacturing employment, only the United Kingdom lost a higher percentage of manufacturing employment during that period.[109] At least six countries with higher average manufacturing wages (Australia, France, Germany, Italy, the Netherlands, and Sweden) outperformed both the United States and the United Kingdom in manufacturing employment retention during these 10 years.[110]

Although manufacturing is the main engine of American innovation, America's historic innovation advantage is eroding. Its share of worldwide totals on a variety of innovation indicators, including domestic R&D investment, new U.S. patents, and science and engineering degrees, fell between the 1980s and the beginning of the 21st century.[111] R&D intensity is lower in the United States than in Israel, Finland, Sweden, South Korea, Japan, Denmark, and Switzerland, and barely ahead of Germany.[112] In addition, as noted earlier in this report, even U.S. manufacturing's advantage in productivity growth over the rest of the domestic economy is not as great as the official statistics indicate.

Unlike the United States, which has a huge trade deficit in goods to which manufacturing is a major contributor, many other advanced countries have trade surpluses in goods. In 2010, Australia, Belgium, Denmark, Finland, Germany, Iceland, Ireland, Japan, New Zealand, Norway, Sweden, and Switzerland had trade surpluses in goods.[113]

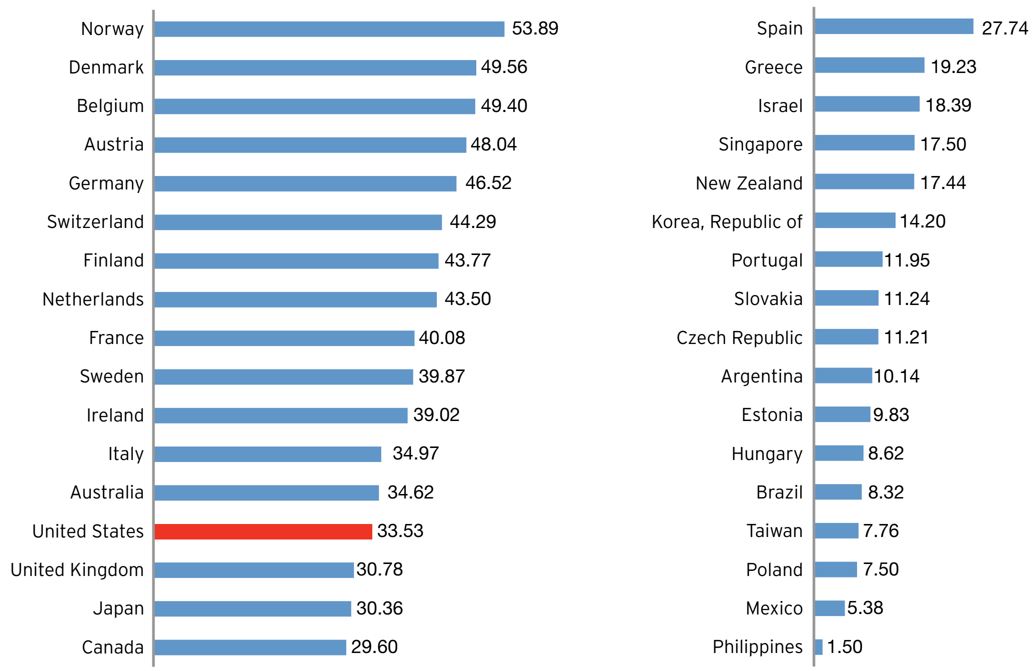
Finally, the United States, once a leader in clean energy manufacturing, is behind China and Japan, and/or South Korea in its production of solar photovoltaic cells and lags China, Japan, and South Korea in the production of lithium-ion batteries.[114] China now spends more than any other country on these technologies and leads the world in deploying conventional wind technologies.[115]

2. An American Manufacturing Policy Should Address Four Major Challenges

American manufacturing faces four major challenges that markets alone cannot address. These challenges are not unique to manufacturing or to the United States. However, the United States, more than other economically advanced countries, lacks well-developed institutions to address them, especially in its manufacturing sector.

The first major problem is support for R&D. The knowledge needed to create new products and production processes inevitably spills over from the company that performs R&D to others who can use it without paying for it. Therefore, individual firms on their own will not perform as much R&D as

Figure 11. Hourly Compensation in Manufacturing in 2009 U.S. Dollars



Source: Bureau of Labor statistics, "International Comparisons of Hourly Compensation Costs in Manufacturing, 2009"; news release, March 8, 2011, Table 1.

society needs.[116] Lack of support for R&D primarily affects manufacturing because, as noted previously, manufacturers perform most R&D in the United States. The United States ranks 22nd out of 30 countries in government-funded research as a share of GDP and 21st in business-funded research as a share of GDP.[117] Moreover, the United States supports very little research on applied problems that are very important to a wide range of small and medium-sized manufacturers, e.g., joining two kinds of materials together.[118] The federal government does not support this kind of research because it primarily funds basic rather than applied research and because the applied research it funds is more relevant to the needs of large firms than to those of smaller ones. Small and medium-sized manufacturers themselves do not fund it, either, because they fund very little formal R&D of any kind.

A second major problem is lack of lifelong training of workers at all levels so that they are equipped to collaborate in designing and implementing innovative products and processes. There is some debate about whether firms are currently observing skill shortages, since wages are not rising, even for occupations thought to be in short supply.[119] However, to adopt the 'high-road' model described above, workers and managers will need more skills. Individual firms are often reluctant to train workers in these skills because the trained workers may leave to work for a competitor before the firm is able to reap the full benefit of its training investment.[120] In some cases, community college vocational programs often offer relevant skills, but they rely significantly on funding from individual firms and, therefore, are subject to the same problem as firms that provide training themselves. Other college-level programs rely on students and their parents for financing, leading to increasingly unsustainable amounts of debt.

Access to finance for firms wishing to make productive investments is another problem for American manufacturing. In some cases, firms have trouble finding capital for good reasons, e.g., they lack a credible plan for providing a return on investment. But in other cases, even firms with strong track records have been unable to find working capital. For instance, numerous small U.S. automotive suppliers were forced to scale back operations dramatically or even go out of business in 2008 and 2009, when many U.S. banks began categorically to deny new financing to auto-dependent firms. This experience showed that U.S. banks were often either unable or unwilling to assess the financial health of individual firms and, therefore, applied cautious financing to healthy and unhealthy automotive suppliers alike. Private equity is taking an increasing role in manufacturing but is more expensive than traditional bank loans and is often unavailable for early-stage companies, which private equity firms perceive as riskier than established companies.[121]

A fourth major problem in manufacturing is a lack of influence of workers and communities in creating and sharing in the gains from innovative manufacturing. Continuous improvement of the production process is a necessity of modern manufacturing. Yet small and medium-sized firms often lack the information they need to carry out continuous improvement, and the federal Manufacturing Extension Partnership program, which helps provide that information, is underfunded and in need of structural change.[122] Production worker involvement in decisionmaking is important to continuous improvement because managers do not have all the shop-floor knowledge that is needed to figure out how to reduce waste and eliminate production bottlenecks. Yet firms may be reluctant to give production workers more say about production decisions out of fear that workers, rather than the firm's owners, will capture most of the resulting productivity gains.[123] Unlike many other advanced industrial countries, the United States does not have an easily accessible means for workers to influence production decisions; the only available means is the legally difficult process of forming a union. Communities as well as workers have limited ability to promote high-road manufacturing. State and local governments often lure manufacturers with substantial tax breaks but have little recourse if firms do not live up to their promises.[124] With shrunken budgets, it is difficult for local governments to provide the education and other services needed by high-road firms.

The United States needs public policies that address these four challenges. Although this report does not recommend specific policies, it is important to lay out principles that should inform such policies. Policies to strengthen American manufacturing should promote high-road production, operate at multiple levels (entire economy, industry, and firm), and promote shared responsibility on the part of employers, workers, unions, and government.

High-road production is the principle that should underlie policies toward worker training and continuous improvement of production. High-road firms pay high wages, which support the high skill levels that production workers need. If public policy makes high wages and skills generally available throughout the economy, then individual firms cannot free-ride on training investments that their competitors make. High-road firms also adopt productivity-enhancing practices and involve workers in production decisionmaking. The resulting rapid productivity growth makes faster wage growth possible, thereby enabling firms and workers to make even greater investments in skill. High-road production's high skill levels also make R&D investments more profitable because the new technologies that can result from R&D often require highly skilled production workers to implement and debug them.

This report has emphasized not only the common strengths (and weaknesses) of American manufacturing but also the ways in which manufacturing industries and firms differ. Manufacturing policy should take these differences into account. What works for pharmaceutical manufacturers may not be appropriate for auto suppliers. The problems that high-road firms face in getting better at high-road production are not the same as the problems that other firms face in getting onto the high road in the first place. Although the problems noted earlier in this section are common to manufacturing as a whole, the details of their solutions need not be. R&D and training needs may differ by technology and industry and, to some extent, by firm. Banks, venture capitalists, and other funders need detailed industry knowledge to assess the viability of loans to or investments in new manufacturing companies. Manufacturers' needs for assistance in improving their manufacturing processes will differ by firm and even by plant.

Finally, public policy should give firms, workers, unions, and government shared responsibility for creating and maintaining a high-wage, innovative, export-intensive, and environmentally sustainable manufacturing sector. Although firms are the most immediate decisionmakers on issues of R&D, finance, and much of worker training, they are not the only actors with a stake in the prosperity of American manufacturing and do not have all the knowledge needed to ensure that prosperity. Workers' skills and knowledge of the production process, the organized worker involvement in decisionmaking that unions make possible, and the public interest as represented by government should also play a role in addressing American manufacturing's challenges.

3. Germany Provides an Example of How to Address Manufacturing's Challenges

The example of Germany is instructive for the United States. Compared to the United States, Germany has achieved better outcomes (higher wages, a slower rate of job loss, and a large trade surplus) for its manufacturing sector. It has done so by creating a set of institutions that address manufacturing's four major challenges and that do so by adhering to the principles of high-road production, multiple levels of policy, and shared responsibility. It is in addressing those challenges and adhering to those principles, not in providing a set of policies that can be transferred wholesale, that Germany can serve as an example for the United States.

German manufacturing wages are higher than U.S. manufacturing wages. In 2009 Germany's average manufacturing wage was $46.52 (in U.S. dollars), compared to $33.53 in the United States.[125] Manufacturing employs a large percentage of Germany's workforce as well. In 2010 manufacturing comprised 21.2 percent of Germany's overall employment and 10.1 percent of America's.[126] Thus, compared to the United States, manufacturing in Germany produces better wages for a larger fraction of workers.

Recent manufacturing job losses have been far smaller in Germany than in the United States. Between 1990 and 2000, German manufacturing employment shrank by 2.2 percent while U.S. manufacturing employment shrank by 7.8 percent.[127] Between 2000 and 2010, Germany lost 6.0 percent of the manufacturing employment it had at the start of the decade; in contrast, the United States lost 28.3 percent of its manufacturing employment.[128] German manufacturing also weathered the Great Recession more effectively, with total manufacturing hours worked declining only 5.6 percent from 2007 to 2010, during which time U.S. manufacturing hours worked declined 16.4 percent.[129]

Manufacturing allows Germany to maintain a notable trade surplus. For the fourth quarter of 2010, Germany reported a $52.3 billion trade surplus while the United States reported a $113.3 billion trade deficit.[130]

Germany's manufacturing success is not accidental; public policy has played an important role. Four main elements make up the German system. First, the federal government has facilitated the formation of rich networks for research and development. Second, German workers and employers benefit from a system of continuous vocational training. Third, German manufacturing firms enjoy stable access to finance. Fourth, sturdy worker protections ensure that instead of solving problems through short-run cost-cutting, German employers and unions work together to adopt high-road solutions that strengthen firm competitiveness in the long term.

Networks for Research and Development. German R&D networks are effective not only because they are well funded (relative to GDP, the German government funds industrial R&D at 20 times the rate at which the United States does) but also because the density of these networks makes each euro of funding more effective.[131] The German R&D network includes firms, universities, public-private research centers (the Fraunhofer Institutes), corporate research institutes, vocational training programs, and unions. Germany is home to over 750 publicly funded research institutions, some of which are federal and some of which operate at the level of the Länder (states). While similar organizations exists in the United States, this infrastructure plays a much more active role in the regular functioning of both large and small German firms; German firms use research universities and technical research agencies, both government-run and private, to help drive their innovation efforts and business strategies.[132] These institutions have received help from several government initiatives such as the High-Tech Strategy, the Higher Education Pact, the Excellence Initiative, and the Joint Initiative for Research and Innovation.

The German tradition of co-operation between business, labor, and research institutes produces higher rates of innovation in many industries.[133] This system enables Germany to maintain the highest number of patent registrations in Europe.[134] These inter-institutional networks are especially strong for robotics and industrial design, allowing German firms to lead in these industries.[135]

The Fraunhofer Institutes, Germany's most important network of research labs, provide a particularly compelling example.[136] Founded in 1949 as a single research center in Munich, Fraunhofer had grown to a network of 57 institutes with 15,000 employees and an annual budget of 1.4 billion euros by 2009.[137] Each Fraunhofer center focuses on a specific research area, and by spawning private sector businesses sometimes serves as the catalyst for a regional innovation hub. For instance, research conducted at the Fraunhofer Institute for Solar Energy Systems in Freiburg, Germany, has spawned at least 14 private companies since its creation in 1981.[138] Years of Fraunhofer research on concentrator photovoltaic (CPV) technology produced technology that enhances solar cell efficiency with lenses and mirrors. In 2005, Fraunhofer researchers founded Concentrix Solar, which now manufactures and sells CPV solar plants in Freiburg.[139] Fraunhofer researchers also invented the MP3, the licensing rights for which have generated billions of euros of revenue for the institutes (100 million alone in 2005).[140]

Fraunhofer centers are often industry-specific because technologies are often industry-specific. However, cross-cutting research institutes help to spread leading-edge technologies (such as biotechnology and nanotechnology) to mature industries (such as food and apparel).[141] Each center combines publicly funded research of broad applicability throughout an industry or technological field with publicly and privately funded contract research that is designed to meet the needs of a particular firm or government agency.

Continuous Vocational Training. The German system of continuous vocational training stems from collaboration between firms, trade unions, and state-run schools.[142] Apprenticeships are common. In 2008, 58 percent of German upper-secondary students were enrolled in a vocational or technical program.[143] These programs can be with a private company or a public vocational institute. Youth participating in apprenticeships usually leave school at age 15 or 16 to spend between two and four years in the program. Apprenticeships vary widely in content and quality, with some paying more dividends to firms and youth than others.[144] While enrolled in an apprenticeship, the young worker divides her time between the classroom and hands-on training, receiving a modest stipend. Employers are willing to devote significant funding to apprenticeship programs; Siemens spends about $220 million per year on its apprenticeship program, in which over 10,000 young workers participate.[145] German firms see this as an investment in innovation; as a representative of the German robotics firm Kuka AG explains, "Students learn and give us ideas around innovation. Also, the students of today are our workers of tomorrow."[146] Although employers are not required to hire apprentices at the end of the program, most apprentices find a job waiting for them.

The apprenticeship program, combined with the fact that many Germans who combine apprenticeships with graduate degrees do not enter the workforce until their late 20's, helps explain why unemployment for Germans under 25 years old hovered around 8 percent in 2009 at a time when youth unemployment climbed to 18 percent in America and over 20 percent in many non-Germanic European countries.[147] Thus, although some fear that high job security will lead to an aging workforce and high unemployment among young people, Germany's system of apprenticeships helps offset these dilemmas. As Thomas Geoghegan concludes, the German system of high job security, high wages, and privately-funded apprenticeships succeeds where America's flexible system fails, in preserving lower unemployment rates and more manufacturing jobs.[148]

In addition, German workers have access to training long after finishing an apprenticeship. The 1969 Vocational Training Act created the "dual system" of training, establishing a framework for both apprenticeships and continued vocational training. For both apprentices and older workers, the dual system (in small part) and a series of federal programs, regional programs, and collective bargaining agreements (in large part) provide workers with a combination of on-the-job training and theoretical training through Germany's network of vocational schools.[149] In 75 percent of German states, workers have the right to up to five days per year of educational leave.[150] This system provides German workers with career-advancing skills, provides firms with access to new skills (which the firm alone is not responsible for funding), and enables the country to re-train its workforce with a level of agility that the United States lacks.

Stable Access to Finance. Many small and mid-sized firms have long-term, exclusive relationships with a local *Hausbank* (house bank).[151] Historically, the trust and institutional knowledge stemming from these close relationships help German firms avoid some of the financing difficulties U.S. manufacturers experience.[152]

Germany also maintains a number of public financial initiatives geared toward small and mid-sized firms (the "Mittelstand"). For instance, the German Central Innovation Program (ZIM) provides funding to small and mid-sized firms, both individually and as groups. This funding is mainly for networking or R&D. The Innovation Program supports "close-to-market research and development of new products and processes" through long-term loans at low interest rates.[153]

Worker Protections and Co-Determination. German laws do much to protect workers' rights, and in doing so create a system in which unions and managers recognize a shared interest in profitability. On a basic level, German workforce protections ensure benefits such as high wages and job security. Yet German workforce policy does not simply regulate "who gets what"; the "co-determination" system also establishes guidelines for who makes decisions at both the firm and industry levels. Workers in each firm with at least five workers can establish a works council, typically a body with union affiliations, which has the right to receive information from, consult with, and in some cases co-determine with the employer on firm-specific issues that are not subject to collective bargaining. Workers or labor representatives are entitled to a certain number of seats on the supervisory boards of joint-stock companies with more than 500 employees.[154] The number of seats to which workers are entitled varies in part by industry, with workers in the steel industry entitled to the greatest board influence. Most collective bargaining around matters including pay, working time, how part-time workers are treated, and training takes place at the industry level, not the firm level. Sixty-two percent of all German workers are covered by collective agreements.

These policies make "low-road" strategies of based on low wages and low training either illegal or unprofitable. Thus, both employers and workers have a shared interest in adopting high road practices to help firms thrive. Historically, this system has enabled unions to create workforce training programs that have been responsive to market shifts. After World War II, German steel firms benefited from workers trained to be more flexible than their American contemporaries, allowing employers to re-allocate workers within a firm in response to technological developments.[155] Unions, especially the metalworkers union (IG Metall) push firms to upgrade by acting as consultants. According to political scientist Gary Herrigel, "The union is simultaneously a broker and a conveyor of specialized knowledge."[156] This system developed in stark contrast to the lack of industry-labor communication in America. Herrigel explains:

> *In the United States, by contrast, there was neither any shop-floor-level institution for labor-management communication, nor were work roles loosely defined or easily rearranged. . . . Workers were not trained to be flexible in American integrated steel factories.*[157]

IG Metall, which also represents many of Germany's automotive workers, now has training programs aimed at re-skilling workers to produce electric cars on a large scale.[158] BMW has signed an agreement with IG Metall, establishing a minimum number of jobs that the company will keep in Germany despite globalization of production.

Most of the policies described above are found throughout the German economy, not just in manufacturing. However, these policies include the promotion of networks (for R&D, finance, training, and worker representation) that are specific to industries, facilitating the development of specialized employees and equipment. Some networks cut across industry boundaries, such as the research institutes that help spread new technologies to mature industries. German policy also has a firm-specific component because it supports institutions that are flexible enough to meet the needs of individual firms and their workers (e.g., Fraunhofer centers' contract research for individual firms, firm-specific apprenticeships, works councils, and banks that have detailed knowledge of the firms they finance).

Germany's policies also contributed to that nation's success in environmental sustainability. Germany has become a leader in solar technology, aided greatly by R&D subsidies, worker training, low-interest loans, and price supports for those installing solar equipment. By 2010, renewable sources accounted for over 20 percent of German electricity generation and 367,000 jobs (not all in manufacturing).[159]

The German example shows that it is possible to use public policy to address the basic challenges of manufacturing and to do so in a way that promotes the critical national goals of high wages, innovation, avoidance of large trade deficits, and environmental sustainability. It also shows that the principles of high-road production, multiple levels of policy, and shared responsibility can inform the design of effective policies.

Manufacturing and high wages can co-exist if policies help firms adopt high-road practices and hinder them from adopting low-road practices. Germany has adopted a particular form of such policies. However, other forms are possible. A notable example is Denmark's "flexicurity" system, in which (unlike in Germany) firms face few obstacles to laying off workers. Instead, active labor market policies help workers find security by easing the transition to new jobs.[160] Regardless of the details of the policy approach, the United States should acknowledge that higher wages do not preclude economic growth. In fact, in many parts of Europe high wages have, in part, enabled systems in which life-long learning contributes to competitive industry, stable employment, and lower income inequality.

Policies that encourage the development of industry-specific competencies are very important in creating competitive manufacturing firms. Germany has a highly organized system of employer associations, unions, and university researchers for almost every industry. In general, German economic development policies do not "pick winners" among industries, targeting resources only to those sectors. Instead German institutions and policies induce or subsidize actors within any industry to come together to develop collaborative training programs, coordinate complex supply chains, and diffuse best practices. The success of such policies does not depend on government bureaucrats having special insight into how to "pick winners." Instead, the industry networks provide a forum for participants to identify blockages that retard innovation and productivity growth in their industry and propose ways of removing them. In so doing they create social networks that build trust, helping firms to learn from each other.[161] Pennsylvania's Industry Partnership Strategy is a good example of a government policy that aims to enhance networks among industry, training institutes, and workers, helping ensure that training programs are responsive to industry needs.[162] Institutes such as the Connecticut Center for Advanced Technology, the Florida Center for Advanced Aero-Propulsion, and the Center for Integrated Manufacturing Studies in Rochester, New York are worth examining as well.[163] By contrast, however, much U.S. economic development policy is premised on the idea that if government provides general training (e.g., college education) to individuals and general tax incentives for investment, markets will somehow connect these individuals together in productive employment. State and local policy tends to focus on "smokestack chasing," paying firms to locate in a particular area, rather than working with existing firms to improve their capabilities.[164]

Policies should build on the idea of shared responsibility between workers, employers, unions, and government. The goal of the system is to create agency and opportunity instead of dependency. Business and policy decisions in Germany often stem from collaborative relationships between corporations, government, and unions. These arrangements provide all actors with incentives to maintain competitive firms that invest domestically in workers, equipment and innovative products and processes.

Policies have complementary effects. Although the details of individual policies may differ, it will be hard for the United States to solve any one of the four problems faced by manufacturing without at least partially addressing the others. For example, increasing support for R&D will not lead to more jobs in the United States without access to finance for innovative firms and a workforce organized to debug problems endemic to the scaling-up of new processes from lab to factory floor. Without more bargaining power for workers and communities, firms will be tempted to introduce new products in locales that offer more favorable subsidies.

It is unrealistic to think that the United States would replicate Germany's densely organized structure, and it is not necessarily true that such a structure would be productive in a U.S. context. However, in a variety of cases firms and local public agencies have created effective decentralized public-private partnerships. For example, six large firms and their smaller suppliers in Wisconsin created a consortium that not only provided training to workers, but built trust and improved collaboration throughout the supply chain on matters such as innovative product design and reduced lead times.[165]

D. Conclusion

Manufacturing provides four important benefits to the U.S. economy:

- Manufacturing pays above-average wages to workers from virtually all demographic groups and all occupational categories.
- Manufacturing promotes innovation: it accounts for the lion's share of R&D spending.
- Manufacturing is a key part of reducing the trade deficit.
- Manufacturing makes a large contribution to environmental sustainability.

Not all manufacturing jobs should be saved. Instead, manufacturing jobs that provide the four national economic benefits discussed above should be preserved and expanded. Certain whole industries stand out for their contributions on these measures (and have been growing in recent years or have strong growth potential); computers and electronics, chemicals (including pharmaceuticals), transportation equipment (including aerospace and motor vehicles and parts), and machinery are especially important. Other industries, such as food processing, are also likely to grow. The nation would benefit from programs that aid firms in all industries in adopting more "high-road" strategies that advance critical national goals.

There are important differences among manufacturing firms within as well as between industries. Some firms in the United States have adopted a "high-road" strategy, in which they harness the knowledge of all workers to promote product and process innovation that supports high productivity and high wages. However, firms are hampered in the adoption of such policies by fragmentation in institutions that support upgrading.

The United States needs a manufacturing policy that will enable more firms to adopt high-road strategies and help existing high-road firms to expand. Such a policy must address four major challenges that modern manufacturing faces: R&D support, worker training, financing of productive investment, and reconstituting mechanisms for creating and sharing productivity improvements In addition to promoting the high road, a U.S. manufacturing policy should be based on the principles of multiple levels of policy (economy-wide, industry-specific, and firm-specific) and shared responsibility on the part of employers, workers, unions, and government.

General policies to improve productivity and wages (such as policies to support education, training, and basic scientific research) are not sufficient. Industry-specific policies are also needed because manufacturing industries, like other industries, are subject to market and policy failures that can be corrected only with considerable industry-specific knowledge and with the participation of firms and other institutions that support the industry. For example, a sectoral approach is necessary to build up simultaneously both the demand for and the supply of shared assets, such as trained workers, competent customers, suppliers of other components, and shared understandings about how to do quality control.[166] This coordinated approach has succeeded in Germany, which both pays significantly higher wages than the United States and runs a trade surplus in manufacturing.

The main challenge to creating a vibrant U.S. manufacturing sector is America's lack of political will to create national manufacturing policy. Explaining the root cause of this inaction is difficult, as other countries with very dissimilar political and economic systems (e.g. China, Japan, Denmark, and Germany) have all developed manufacturing strategies.

Some argue that U.S. manufacturing will eventually achieve its proper size and composition all by itself. It may have been "hard hit" by the recent recession, but will "bounce back" automatically once exchange rates find their correct level or externally generated technological advances help firms overcome labor-cost disadvantages.[167] However, this optimism is misguided. As the shoe example of Box 3 shows, it is very hard to revive an industry after its sales and employment have dramatically shrunk. Once the dense network of suppliers disappears, the fall in the dollar required to justify reinvestment is much greater than that necessary to expand existing operations—meaning an even greater fall in the standard of living.[168] The frayed production networks in such industries as tooling and electronics should be cause for great concern.[169] Thus, the sooner the United States acts to shore up its manufacturing sector, the easier it will be.

Table 1. Average Weekly Earnings in Manufacturing and Non-Manufacturing Industries, Controlling for Worker and Job Characteristics, 2008-2010*

	Manufacturing	Non- manufacturing**	Percent Difference
Overall	$605.18	$558.29	8.4
Wage group* **			
Low-wage workers	$453.95	$408.49	11.1
Middle-wage workers	$607.40	$564.85	7.5
High-wage workers	$821.82	$791.73	3.8
Gender			
Male	$614.50	$574.50	7.0
Female	$478.30	$461.20	3.7
Race and ethnicity			
White	$614.50	$574.50	7.0
Black	$543.40	$519.60	4.6
Hispanic	$523.50	$523.60	-0.0
Asian	$619.30	$580.20	6.7
Other	$563.90	$551.40	2.3
Educational Attainment			
No high school diploma	$426.50	$402.00	6.1
High school diploma	$614.50	$574.50	7.0
Some college	$602.40	$562.00	7.2
Associate degree	$684.70	$676.50	1.2
Bachelor's degree or more	$952.00	$890.10	7.0
Major Occupation			
Management, business, and financial	$1,051.00	$949.40	10.7
Professional and related	$905.60	$756.80	19.7
Service	$455.20	$437.10	4.1
Sales and related	$649.20	$521.50	24.5
Office and administrative support	$620.70	$569.20	9.0
Farming, fishing, and forestry	$595.40	$471.50	26.3
Construction and extraction	$758.40	$715.00	6.1
Installation, maintenance, and repair	$774.60	$725.30	6.8
Production	$614.50	$574.50	7.0
Transportation and material moving	$587.10	$559.20	5.0

**Average weekly earnings shown in the table are predicted values from regressions that control, as appropriate for each, for age (including powers up to the fourth power), race, sex, educational attainment, foreign-born status, marital status, ownership of establishment (public, private, non-profit), metropolitan or non-metropolitan area, union coverage, part-time or full-time, occupation, industry, and usual weekly work hours. The reference group is defined as: male, white, non-Hispanic, high school graduate, native-born, employed by a private for-profit firm, married, living in a metropolitan area in the Midwest, not covered by a union contract, employed full-time, in a production occupation, in the non-manufacturing sector. Age and wage levels are evaluated at sample means for each demographic and occupational group. Observations with imputed values are omitted from the sample.*

***Non-manufacturing includes government.*

****Low-wage workers are those who earn more than 20 percent of all workers and less than 80 percent. Middle-wage workers are those who earn more than half of all workers and less than half. High- wage workers are those who earn more than 80 percent of all workers and less than 20 percent. These wage categories are defined separately for manufacturing and non-manufacturing workers.*

Source: Analysis of combined Current Population Survey outgoing rotation groups for 2008-2010, conducted by Mark Price of the Keystone Research Center

Appendix

Table 2. Average Weekly Earnings in Manufacturing Industries and Non-manufacturing, Controlling for Worker and Job Characteristics, 2008-2010*

Industry	Average Weekly Earnings
Petroleum refining	$742.41
Aerospace products and parts manufacturing	$700.50
Tobacco manufacturing	$695.86
Pharmaceutical and medicine manufacturing	$690.24
Computer and peripheral equipment manufacturing	$681.76
Engines, turbines, and power transmission equipment manufacturing	$677.03
Agricultural chemical manufacturing	$669.83
Industrial and miscellaneous chemicals	$662.82
Communications, audio, and video equipment manufacturing	$660.75
Navigational, measuring, electromedical, and control instruments manufacturing	$653.16
Household appliance manufacturing	$650.79
Aircraft and parts manufacturing	$649.81
Pulp, paper, and paperboard mills	$647.64
Construction, mining and oil field machinery manufacturing	$643.40
Motor vehicles and motor vehicle equipment manufacturing	$633.24
Cement, concrete, lime, and gypsum product manufacturing	$625.35
Not specified machinery manufacturing	$624.95
Electronic component and product manufacturing, n.e.c.	$623.97
Metalworking machinery manufacturing	$622.69
Foundries	$622.49
Miscellaneous petroleum and coal products	$620.61
Paint, coating, and adhesive manufacturing	$620.32
Sawmills and wood preservation	$614.01
Iron and steel mills and steel product manufacturing	$612.82
Nonferrous metal, except aluminum, production and processing	$611.74
Machine shops; turned product; screw, nut and bolt manufacturing	$610.06
Ship and boat building	$608.98
Tire manufacturing	$608.78
Medical equipment and supplies manufacturing	$606.61
Machinery manufacturing, n.e.c.	$606.02
Manufacturing average	$605.18
Aluminum production and processing	$598.62
Soap, cleaning compound, and cosmetics manufacturing	$598.33
Animal food, grain and oilseed milling	$595.76
Ordnance	$595.47
Not specified metal industries	$595.37
Sugar and confectionery products	$591.52
Miscellaneous nonmetallic mineral product manufacturing	$591.52
Footwear manufacturing	$591.03
Commercial and service industry machinery manufacturing	$589.65
Dairy product manufacturing	$589.45
Carpet and rug mills	$589.06
Resin, synthetic rubber and fibers, and filaments manufacturing	$589.06
Not specified food industries	$588.86
Fiber, yarn, and thread mills	$587.28
Miscellaneous fabricated metal products manufacturing	$585.11
Miscellaneous paper and pulp products	$585.01
Plastics product manufacturing	$584.42

Industry	Average Weekly Earnings
Animal slaughtering and processing	$583.83
Electrical lighting, equipment, and supplies manufacturing, n.e.c.	$582.74
Beverage manufacturing	$579.98
Structural metals, and tank and shipping container manufacturing	$574.86
Other transportation equipment manufacturing	$573.47
Railroad rolling stock manufacturing	$573.18
Seafood and other miscellaneous foods, n.e.c.	$572.98
Fruit and vegetable preserving and specialty food manufacturing	$569.92
Printing and related support activities	$569.63
Fabric mills, except knitting	$565.88
Glass and glass product manufacturing	$565.68
Agricultural implement manufacturing	$565.68
Metal forgings and stampings	$563.81
Rubber products, except tires, manufacturing	$559.27
Furniture and related product manufacturing	$558.78
Non-manufacturing average**	$558.29
Pottery, ceramics, and related products manufacturing	$558.19
Prefabricated wood buildings and mobile homes	$557.89
Paperboard containers and boxes	$555.13
Miscellaneous wood products	$555.13
Veneer, plywood, and engineered wood products	$554.24
Coating, engraving, heat treating and allied activities	$550.79
Structural clay product manufacturing	$549.31
Cutlery and hand tool manufacturing	$549.21
Miscellaneous manufacturing, n.e.c.	$548.13
Toys, amusement, and sporting goods manufacturing	$537.08
Textile and fabric finishing and coating mills	$536.39
Bakeries, except retail	$527.81
Textile product mills, except carpets and rugs	$512.23
Leather tanning and products, except footwear manufacturing	$511.34
Knitting mills	$499.90
Apparel accessories and other apparel manufacturing	$495.07
Cut and sew apparel manufacturing	$494.87
Retail bakeries	$489.55

Note: n.e.c=not elsewhere classified.

**Average weekly earnings shown in the table are predicted values from regressions that control, as appropriate for each, for age (including powers up to the fourth power), race, sex, educational attainment, foreign-born status, marital status, ownership of establishment (public, private, non-profit), metropolitan or non-metropolitan area, union coverage, part-time or full-time, occupation, industry, and usual weekly work hours. The reference group is defined as: male, white, non-Hispanic, high school graduate, native-born, employed by a private for-profit firm, married, living in a metropolitan area in the Midwest, not covered by a union contract, employed full-time, in a production occupation, in the non-manufacturing sector. Age and wage levels are evaluated at sample means. Observations with imputed values are omitted from the sample.*

***Non-manufacturing includes government.*

Source: Analysis of combined Current Population Survey outgoing rotation groups for 2008-2010, conducted by Mark Price of the Keystone Research Center

Table 3. Percent of Private Sector Workers Participating in Selected Employee Benefits, 2006

Benefit	Goods-producing industries (%)	All private industry (%)
Retirement plans	64	51
Defined benefit plans	31	20
Defined contribution plans	51	43
Paid holidays*	85	76
Life insurance	60	50
Medical care	70	52
Paid sick leave*	48	57
Paid vacations	86	77

**Percent of workers with access to benefit, not those participating in it.*

Source: Authors' analysis of Bureau of Labor Statistics Employee Benefit Survey data

Table 4. Percent of Manufacturing Companies Introducing New Products and Processes, 2006-2008.

Industry	Percent introducing new or significantly improved product	Percent introducing new or significantly improved process
Navigational/measuring/electromedical/control instruments	59	40
Computers and peripheral equipment	56	46
Communications equipment	51	33
Pharmaceuticals and medicines	45	42
Other chemicals	40	31
Other computer and electronic products	37	14
Electrical equipment/appliances/components	37	28
Other transportation equipment	35	25
Aerospace products and parts	32	25
Semiconductor/other electronic components	27	25
Machinery	26	24
Plastics and rubber products	24	28
Motor vehicles/trailers/parts	24	22
Other manufacturing	22	23
All manufacturing	22	22
Textile/apparel/leather and allied products	19	18
Food	17	17
Beverage and tobacco products	17	15
Primary metals	17	19
Fabricated metal products	16	22
Furniture and related products	14	19
Nonmetallic mineral products	13	14
Wood products	9	16

Source: National Science Foundation, Division of Science Resources Statistics, Business R&D and Innovation Survey, 2008

Table 5. U.S. Domestic Company R&D Intensity in Manufacturing Industries, 2006-2008.

Industry	R&D intensity (percent)*
Semiconductor/other electronic components	20.9
Communications equipment	13.9
Pharmaceuticals and medicines	11.9
Computers/peripheral equipment	7.1
Other computer and electronic products	6.1
Navigational/measuring/electromedical/control instruments	5.6
All manufacturing	3.6
Machinery	3.6
Aerospace products/parts	3.0
Motor vehicles/trailers/parts	2.5
Electrical equipment/appliances/components	2.5
Other transportation equipment	2.1
Other chemicals	1.7
Other manufacturing	1.7
Nonmetallic mineral products	1.6
Fabricated metal products	1.6
Furniture and related products	1.4
Plastics and rubber products	1.4
Food	0.9
Beverage and tobacco products	0.6
Wood products	0.6
Textile/apparel/leather and allied products	0.6
Primary metals	0.4

**U.S. domestic company R&D spending (paid for by company) as percent of domestic sales.*

Source: Authors' analysis of National Science Foundation, Division of Science Resources Statistics, Business R&D and Innovation Survey, 2008

Table 6. Architecture and Engineering Occupations as Percent of Total Employment in Manufacturing Industries, 2010

Industry	Percent
Aerospace Products and Parts	21.3
Computer and Electronic Products	21.2
Other transportation equipment	10.7
Machinery	9.5
Electrical Equipment/Appliances/Components	9.4
Petroleum and Coal Products	8.2
Motor Vehicles and Parts	7.1
All Manufacturing	6.2
Other Chemicals	5.3
Miscellaneous Manufacturing	4.6
Pharmaceuticals and Medicines	4.5
Primary Metals	3.7
Fabricated Metal Products	3.7
Plastics and Rubber Products	3.1
Nonmetallic Mineral Products	1.9
Paper	1.8
Furniture and Related Products	1.8
Wood Products	1.3
Textile Mills	1.2
Leather and Allied Products	0.8
Beverage and Tobacco Products	0.6
Textile Product Mills	0.6
Food	0.4
Apparel	0.2
Printing and Related Support Activities	0.1

Source: Authors' analysis of Bureau of Labor Statistics Occupational Employment Survey, May 2010

Table 7. Manufacturing Utility Patents of U.S. Origin by Industry, as Percent of All Manufacturing Utility Patents of U.S. Origin, 2008

Industry	Percent
Computers and Peripheral Equipment	16.4
Semiconductors and Other Electronic Components	12.5
Navigational/Measuring/Electromedical/Control	11.5
Communications Equipment	10.8
Machinery	9.9
Other Chemicals	6.3
Electrical Equipment/Appliances/Components	6.3
Other Miscellaneous Manufacturing	4.8
Fabricated Metal Products	4.3
Pharmaceuticals and Medicines	3.5
Medical Equipment and Supplies	2.7
Motor Vehicles and Parts	2.3
Plastics and rubber products	2.1
Audio/video and magnetic/optical media	2.1
Textile Mills, Textile Product Mills, and Apparel	0.9
Nonmetallic Mineral Products	0.9
Aerospace Products and Parts	0.7
Other Transportation Equipment	0.7
Furniture and Related Products	0.4
Paper and Printing	0.3
Primary Metals	0.3
Wood Products	0.2
Food	0.1
Beverage and Tobacco Products	0.0

Note: Patents are assigned to NAICS industry codes by the fractional method, i.e., each patent is allocated to one or more industries and the fraction assigned to each industry is counted in that industry's total. These assignments are rough approximations.

Source: Authors' analysis of U.S. Patent and Trademark Office Data

Table 8. Productivity Growth Rates in Manufacturing Industries, 1997-2007, Adjusted for Increased Offshoring

Industry	Annual productivity growth rate (%)
Computer and Electronic Products	24.24
Motor Vehicles and Parts	5.49
All manufacturing	4.82
Miscellaneous Manufacturing	4.77
Apparel and Leather and Allied Products	4.72
Textile Mills and Textile Product Mills	4.20
Chemicals*	4.20
Machinery	4.00
Electrical Equipment/Appliances/Components	3.94
Other Transportation Equipment**	3.32
Printing and Related Support Activities	3.09
All Manufacturing without Computer and Electronic Products	2.80
Wood Products	2.48
Furniture and Related Products	2.20
Primary Metals	2.09
Fabricated Metal Products	1.51
Paper	1.29
Plastics and rubber products	1.25
Food, Beverage, and Tobacco Products	0.82
Nonmetallic Mineral Products	0.53
Petroleum and Coal Products	-0.29

**Includes pharmaceuticals and medicines.*

***Includes aerospace products and parts.*

Note: It is not possible to adjust productivity growth rates in individual manufacturing industries for the increased use of temporary help services.

Source: Authors' analysis of Bureau of Economic analysis data, published and unpublished Bureau of Labor Statistics data, and Susan Houseman and others, "Offshoring Bias in U.S. Manufacturing: Implications for Productivity and Value Added," International Finance Discussion paper No. 1007 (Washington: Board of Governors of the Federal Reserve System, 2010). See note 30 for details.

Table 9. Trade Balance, 2010, and Change in Trade Balance, 2001-2010, for Manufacturing Industries (millions of dollars)

Industry	Trade balance, 2010	Change in trade balance, 2001-2010
Transportation Equipment**	-$51,407	$29,917
Machinery	29,155	20,294
Chemicals*	12,130	9986
Petroleum and Coal Products	-9053	6933
Paper	2440	6123
Wood Products	-6083	4788
Food	10,823	3504
Textile Mills	1614	606
Printing and Related Support Activities	1090	106
Nonmetallic Mineral Products	-6326	-514
Fabricated Metal Products	-11,463	-5581
Miscellaneous Manufacturing	-36,470	-5658
Beverage and Tobacco Products	-10,308	-5708
Textile Product Mills	-12,979	-7450
Furniture and Related Products	-20,732	-8046
Primary Metals	-25,639	-8133
Plastics and rubber products	-8687	-8164
Leather and Allied Products	-27,799	-8864
Electrical Equipment/Appliances/Components	-28,986	-14,584
Apparel	-71,167	-15,622
Computer and Electronic Products	-144,584	-104,433
All manufacturing	**-414,431**	**-110,320**

**Includes pharmaceuticals and medicines.*

***Includes motor vehicles/trailers/parts and aerospace products and parts.*

Source: Authors' analysis of U.S. International Trade Commission data

Table 10. Manufacturing Industries Gaining Jobs, 2001-2009

	2001 Employment	2009 Employment	Percent change, 2001-2009
Ethyl alcohol manufacturing	3,254	9,603	195.1
Plastics packaging film and sheet mfg.	5,571	11,533	107.0
Military armored vehicles and tank parts mfg.	5,455	10,427	91.2
Other ordnance and accessories manufacturing	3,652	5,903	61.6
Wineries	25,363	40,100	58.1
Perishable prepared food manufacturing	22,672	34,048	50.2
In-vitro diagnostic substance manufacturing	13,233	19,477	47.2
Small arms ammunition manufacturing	7,228	9,872	36.6
Spice and extract manufacturing	15,252	19,501	27.9
Oil and gas field machinery and equipment	47,618	60,360	26.8
Custom architectural woodwork and millwork	13,293	16,494	24.1
Ground or treated minerals and earths mfg.	4,665	5,731	22.9
Space vehicle propulsion units and parts mfg.	12,053	14,638	21.5
Digital printing	19,338	22,935	18.6
Creamery butter manufacturing	1,861	2,204	18.4
Tortilla manufacturing	14,885	17,521	17.7
Coffee and tea manufacturing	12,235	14,294	16.8
Turbine and turbine generator set units mfg.	22,612	26,093	15.4
Cut stone and stone product manufacturing	20,876	23,832	14.2
Women's and girls' blouse and shirt mfg	7,233	8,235	13.9
Irradiation apparatus manufacturing	11,569	13,017	12.5
Plastics bag and pouch manufacturing	27,341	30,760	12.5
Frozen cakes and other pastries manufacturing	9,361	10,517	12.4
Cane sugar refining	2,959	3,305	11.7
Small arms manufacturing	9,618	10,742	11.7
Ship building and repairing	91,003	101,251	11.3
Soybean processing	10,238	11,363	11.0
Electromedical apparatus manufacturing	53,813	59,296	10.2
Roasted nuts and peanut butter manufacturing	11,135	12,260	10.1
Other biological product manufacturing	23,887	26,131	9.4
Metal tank, heavy gauge, manufacturing	25,840	28,217	9.2
Other nonferrous foundries, exc. die-casting	6,186	6,748	9.1
Surgical appliance and supplies manufacturing	90,948	98,907	8.8
Surgical and medical instrument manufacturing	107,039	115,282	7.7
Cheese manufacturing	37,809	39,753	5.1
Distilleries	6,915	7,189	4.0
Guided missile and space vehicle mfg.	53,330	55,303	3.7
Dog and cat food manufacturing	19,329	19,866	2.8
Explosives manufacturing	6,450	6,620	2.6
Power boiler and heat exchanger manufacturing	21,795	22,118	1.5
Search, detection, and navigation instruments	148,388	150,415	1.4
Meat processed from carcasses	109,221	110,148	0.9
Petroleum refineries	74,977	75,588	0.8
Other aircraft parts and equipment	97,634	98,308	0.7
Fats and oils refining and blending	5,965	5,993	0.5

Source: Authors' analysis of Bureau of Labor Statistics Quarterly Census of Employment and Wages data

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Endnotes

1. Susan Helper is Carlton Professor of Economics at Case Western Reserve University. Timothy Krueger is a research assistant at Policy Matters Ohio. Howard Wial is an economist and fellow in the Metropolitan Policy Program at the Brookings Institution.

2. Authors' analysis of Bureau of Labor Statistics Current Employment Statistics data.

3. Ibid.

4. Authors' analysis of Bureau of Labor Statistics Current Employment Statistics data.

5. Ibid.

6. Ibid. During this period, the inflation-adjusted hourly wage fell by 1.7 percent in manufacturing, compared with 1.2 percent in the private sector as a whole.

7. Stephen S. Cohen and John Zysman, *Manufacturing Matters* (New York: Basic, 1987).

8. Robert B. Reich, "Manufacturing Jobs Are Never Coming Back," *Forbes.com*, May 28, 2009, available at www.forbes.com/2009/05/28/robert-reich-manufacturing-business-economy.html.

9. Jagdish Bhagwati, "The Manufacturing Fallacy," *The American Interest*, August 31, 2010, available at http://blogs.the-american-interest.com/bhagwati/2010/08/31/the-manufacturing-fallacy. Similarly, Richard Longworth has argued that America's historic Great Lakes manufacturing belt will have to depend increasingly on innovative services rather than manufacturing. See Richard C. Longworth, *Caught in the Middle* (New York: Bloomsbury, 2008).

10. Steven Pearlstein. "Wage Cuts Hurt, but They May Be the Only Way to Get Americans Back to Work," *Washington Post*, Oct 12, 2010, available at www.washingtonpost.com/wp-dyn/content/article/2010/10/12/AR2010101206121.html.

11. Overviews of these arguments can be found in Stephen J. Ezell and Robert D. Atkinson, "The Case for a National Manufacturing Strategy" (Washington: Information Technology and Innovation Foundation, 2011), and Michael Ettlinger and Kate Gordon, "The Importance and Promise of American Manufacturing" (Washington: Center for American Progress, 2011).

12. We do not address the argument that manufacturing is essential to national defense because others have provided excellent overviews. See Ezell and Atkinson, "Case," and, for a more detailed treatment, Joel S. Yudken, "Manufacturing Insecurity," report prepared for Industrial Union Council, AFL-CIO (Arlington, VA: High Road Strategies, 2010), available at www.highroadstrategies.com/downloads/DefIndustrial-Base-Report-FIN.pdf.

13. Concrete policy proposals can be found in Susan Helper and Howard Wial, "Strengthening American Manufacturing: A New Federal Approach" (Washington: Brookings Institution, 2010); Susan Helper and Howard Wial, "Accelerating Advanced Manufacturing With New Research Centers" (Washington: Brookings Institution, 2011); Susan Helper and Marcus Stanley, "Creating Innovation Networks Among Manufacturing Firms: How Effective Extension Programs Work," in *Economic Development through Entrepreneurship: Government, University and Business Linkages*, edited by Scott Shane (Northampton, MA: Edward Elgar, 2005), pp. 50-62; Susan Helper, "The High Road for U.S. Manufacturing," *Issues in Science and Technology* 25 (Winter 2009), available at www.issues.org/25.2/helper.html; Patricia Atkins and others, "Responding to Manufacturing Job Loss: What Can Economic Development Policy Do?" (Washington: Brookings Institution, 2011).

14. Analysis of combined Current Population Survey outgoing rotation groups for 2008-2010, conducted by Mark Price of the Keystone Research Center. Because manufacturing, as defined in the North American Industrial Classification System (NAICS), includes only business establishments whose main activity is production of goods, these estimates do not include the wages of many highly paid engineers and managers who work in the separate headquarters and R&D centers of many manufacturing

companies. If the latter establishments were included (something that is not possible in NAICS), then manufacturing wages would be even higher compared to non-manufacturing wages. Similarly, the data do not include the substantial number of workers who work in manufacturing plants but are on the payrolls of temporary help services. See Matthew Dey, Susan N. Houseman, and Anne E. Polivka, "Manufacturers' Outsourcing to Temporary Help Services," Upjohn Institute Working Paper No. 07-132 (Kalamazoo, MI: Upjohn Institute for Employment Research, 2006).

15. These characteristics include union representation. Our analysis shows that on average unionized workers in both manufacturing and non-manufacturing industries earn about 15 percent more than nonunion workers with the same demographic and occupational characteristics.

16. Hispanics' very slightly lower wage in manufacturing (amounting to just $5.20 annually for a year-round worker) may result from a concentration of Hispanics in lower-paying manufacturing industries.

17. It may be surprising to learn that there are 31,000 farming /fishery/forestry workers in manufacturing. According to our analysis of Bureau of Labor Statistics Occupational Employment Statistics data for May 2010, about a third of them are graders and sorters of agricultural products, 17 percent are farmworkers for farm/ranch/aquacultural animals, and 15 percent work in nurseries and greenhouses. About 64 percent of them are in food manufacturing (half of those being in slaughterhouses), 18 percent in wood products, and 14 percent in beverage manufacturing.

18. According to our analysis of Bureau of Labor Statistics Quarterly Census of Employment and Wages data, these industries combined employed just under 10 percent of the nation's nearly 11.5 million manufacturing workers in 2010.

19. Analysis of combined Current Population Survey outgoing rotation groups for 2008–2010, conducted by Mark Price of the Keystone Research Center.

20. Authors' analysis of Bureau of Labor Statistics 2010 Quarterly Census of Employment and Wages data.

21. See Simon D. Woodcock, "Wage Differentials in the Presence of Unobserved Worker, Firm, and Match Heterogeneity," *Labour Economics* 15 (2008): 774-98; George Borjas and Valerie Ramey, "Market Responses to Interindustry Wage Differentials," NBER Working Paper 7799 (Cambridge, MA: National Bureau of Economic Research, 2000); Alan B. Krueger and Lawrence H. Summers, "Efficiency Wages and the Inter-Industry Wage Structure," *Econometrica* 56 (1988): 259-293.

22. According to our analysis of Bureau of Economic Analysis industry accounts data, capital (measured as gross operating surplus plus taxes on production and imports less subsidies) per worker was 21 percent higher in manufacturing than in the economy as a whole in 2009.

23. The data provide little support for other theories of the manufacturing wage premium. One possibility is that manufacturing jobs are more unpleasant or unsafe than other jobs, and thus workers require higher pay to work in this sector. However, studies of inter-industry wage differentials find that at most a small part of the manufacturing wage premium is explained by this argument. (See, e.g., Borjas and Ramey, "Market Responses"; Krueger and Summers, "Efficiency Wages.") Another possibility is that workers have important characteristics that we did not control for above and that are important in determining wages. However, evidence suggests that these unobserved characteristics are less favorable in manufacturing. This can be inferred by looking at what happens to wages when an individual worker moves between jobs, controlling for the observable characteristics discussed above. On average, when a worker takes a job in manufacturing, her wages rise; if that worker's next job is outside manufacturing, her wages fall. (See Woodcock, "Wage Differentials.") A different approach to measuring skills not captured by education and work experience is to control for job content. This approach also finds small effects; controlling for job content increases the estimated wage premium in some manufacturing industries and reduces it slightly in others. See table 2 in Maury Gittleman and Brooks Pierce, "Inter-industry wage differentials, job content, and unobserved ability," *Industrial and Labor Relations Review* 64 (2011): 356-72. A third possibility is that unions bid wages up. However, the manufacturing wage differentials shown in Appendix table 1 and discussed in the text included controls for union status. Thus, the manufacturing wage advantage that we have illustrated does not result from the fact that manufacturing workers are more likely to be represented by unions than are other private sector workers. However, we cannot rule out the possibility that the extent of unionization in manufacturing throughout the local geographic area where a worker is employed (as distinguished from whether or not that worker is represented by a union) is partially responsible for the union wage premium in manufacturing. For an analysis of the wage impact of geographic as distinguished from individual differences in union representation, see Bruce Western and Jake Rosenfeld, "Unions, Norms, and the Rise in U.S. Wage Inequality," *American Sociological Review* 76 (2011): 513-537.

24. Since this high-road approach is preferable for the economy as a whole, not just for manufacturing, the strategy would have ambiguous effects on the manufacturing wage premium.

25. Analysis of combined Current Population Survey outgoing rotation groups for 2008-2010, conducted by Mark Price of the Keystone Research Center, shows that in manufacturing, 12.1 percent of workers have less than a high school diploma and 36.1 percent have a high school diploma but no further schooling. Outside of manufacturing, 9.9 percent of workers have less than a high school diploma and 27.2 percent have a high school diploma but no further schooling.

26. Mark Boroush, "NSF Introduces New Statistics on Business Innovation," NSF 11-300 (Arlington, VA: National Science Foundation, 2010).

27. Authors' analysis of National Science Foundation, Division of Science Resources Statistics, Business R&D and Innovation Survey, 2008. Note that companies performing domestic R&D spending are not all domestically owned companies, so some of this R&D includes investment from companies based in other countries.

28. Authors' analysis of Bureau of Labor Statistics Current Employment Statistics and Occupational Employment Statistics data.

29. Authors' analysis of data in Houseman and others, "Offshoring Bias," table 9.

30. For further discussion of the influence of the computers and electronics industry on officially measured productivity growth in manufacturing, see Ezell and Atkinson, "Case"; Robert W. Crandall, "The Decline in U.S. Manufacturing Before and During the Current Crisis," *L'Industria* 30 (2009): 679-701.

31. Michael Mandel and Susan Houseman, "Not All Productivity Gains are the Same. Here's Why" (New York: McKinsey and Company, 2011).

32. Susan Houseman and others, "Offshoring Bias in U.S. Manufacturing," *Journal of Economic Perspectives* 25 (2011): 111-132.

33. Dey, Houseman, and Polivka, "Manufacturers' Outsourcing."

34. See Robert Atkinson and Howard Wial, "Boosting Productivity, Innovation, and Growth through a National Innovation Foundation" (Washington: Brookings Institution and Information Technology and Innovation Foundation, 2008).

35. Our estimates are of growth in labor productivity, measured as inflation-adjusted value added per hour worked. We used the corrected estimates of value added in manufacturing industries found in Susan Houseman and others, "Offshoring Bias in U.S. Manufacturing: Implications for Productivity and Value Added," International Finance Discussion Paper No. 1007 (Washington: Board of Governors of the Federal Reserve System, 2010), table 9. We averaged the highest and lowest corrected estimates for each industry. Our data on work hours in each industry came from published and unpublished Bureau of Labor Statistics data. For all private business we measured labor input as the number of full-time equivalent employees, as estimated by the Bureau of Economic Analysis, All growth estimates are logarithmic changes.

36. N. Gregory Mankiw and Phillip Swagel, "The Politics and Economics of Offshore Outsourcing," NBER Working Paper 12398 (Cambridge, MA: National Bureau of Economic Research, 2006).

37. Ezell and Atkinson, "Case."

38. Ibid.

39. Brian Fifarek, Francisco Veloso, and Cliff Davidson, "Offshoring Technology Innovation: A Case Study of Rare-earth Technology," *Journal of Operations Management* 26 (2008): 222-238.

40. Gregory Tassey, "Rationales and Mechanisms for Revitalizing U.S. Manufacturing R&D Strategies," *Journal of Technology Transfer* 35 (2010): 283-333.

41. Willy C. Shih, "The U.S. Can't Manufacture the Kindle and That's a Problem," *Harvard Business Review* Blog Network, October 2009, available at http://blogs.hbr.org/hbr/restoring-american-competitiveness/2009/10/the-us-cant-manufacture-the-ki.html.

42. Ibid.

43. Reich, "Manufacturing Jobs."

44. Ibid.

45. Authors' analysis of Bureau of Labor Statistics Current Employment Statistics data.

46. William Nordhaus, "The Sources of the Productivity Rebound and the Manufacturing Employment Puzzle."

NBER Working Paper 11354 (Cambridge, MA: National Bureau of Economic Research, 2005). The authors replicated Nordhaus' work for the 2001-2009 period.

47. Bureau of Labor Statistics, "International Comparisons of Manufacturing Productivity and Unit Labor Cost Trends," News Release, December 21, 2010, table 1; and authors' analysis of data in Bureau of Labor Statistics, "International Comparisons of Annual Labor Force Statistics, Adjusted to U.S. Concepts, 10 Countries, 1970-2010," table 2-4.

48. For more detail on the survey, see Susan Helper and others, "The U.S. Auto Supply Chain at a Crossroads," report prepared for U.S. Department of Labor, 2011 (Cleveland: Case Western Reserve University, n.d.), available at http://drivingworkforcechange.org/reports/supplychain.pdf.

49. Japan and Germany are good examples of this concept in a historical sense, as they have maintained similar shares of global manufacturing business from 1970 to the present despite the emergence of many low-cost competitor nations during the past four decades. See Ezell and Atkinson, "Case." South Korea and Taiwan provide good short-term examples of how countries can increase their share of global manufacturing and thereby grow manufacturing employment even while global demand shrinks. According to Bureau of Labor Statistics International Labor Comparisons data, these two countries increased both their output and total hours worked between 2008 and 2010 – a period during which the United States lost ground by both measures.

50. Authors' analysis of Bureau of Economic Analysis national income and product accounts and international transactions data. We define the trade deficit here as the deficit on goods and services combined, as shown in the international transactions data.

51. Ibid.

52. Authors' analysis of Federal Reserve Board foreign exchange rate data.

53. Paul Krugman has estimated that China's manipulation of its currency is responsible for the loss of 1.4 million U.S. jobs, most of them in manufacturing. Paul Krugman, "Macroeconomic Effects of Chinese Mercantilism," *New York Times*, Dec 31, 2009, available at http://krugman.blogs.nytimes.com/2009/12/31/macroeconomiceffects-of-chinese-mercantilism.

54. Robert Scott, "Costly Trade With China: Millions of U.S. Jobs Displaced With Net Job Loss in Every State" (Washington: Economic Policy Institute, 2007). Another study using a different method found that rising competition from Chinese imports explains one fourth of the manufacturing job loss over the period since China joined the World Trade Organization, or almost 900,000 jobs. This study also estimates the gains from such trade, and concludes that these gains may well not be big enough to compensate those who lost jobs and wages because of it. See David H. Autor, David Dorn, and Gordon Hanson, "The China Syndrome: Local Labor Market Effects of Import Competition in the United States," MIT Department of Economics working paper, 2011.

55. Authors' analysis of U.S. International Trade Commission (USITC) data on trade in goods and Bureau of Economic Analysis (BEA) international transactions data. Because USITC data cover manufacturing and other goods but not services, while BEA data cover goods and services but do not separate manufacturing from other goods, manufacturing estimates are made comparable to total trade estimates by multiplying USITC manufacturing estimates by the ratio of BEA to USITC estimates for all goods. Manufacturing includes all NAICS manufacturing categories plus Harmonized Trade Schedule categories 9809 and 9880 for exports and 9817 and 9999 for imports, which consist entirely or almost entirely of manufactured goods. All estimates are for the year 2010.

56. These estimates are based on the authors' analysis of U.S. International Trade Commission data on trade in goods and Bureau of Economic Analysis international transactions data. In each scenario, exports and imports in the other two categories are assumed to grow over the 2010-2019 period at their 2001-2010 rates. Manufacturing trade estimates are adjusted as described in note 55.

57. Authors' analysis of data in U.S. Energy Information Administration, *Monthly Energy Review,* October 2011, available at www.eia.gov/totalenergy/data/monthly/#naturalgas; Jonathan G. Dorn, "Run Cars on Green Electricity, Not Natural Gas" (Washington: Earth Policy Institute, 2008), available at www.earth-policy.org/plan_b_updates/2008/update79.

58. Countries with the highest policy barriers to service imports include China, India, and Indonesia. See Batshur Gootiiz and Aaditya Mattoo, "Services in Doha: What's On the Table?" World Bank Policy Research Working Paper 4903 (Washington: World Bank, 2009). Restrictions include such policies as limitations on foreign ownership of service providers and general entry barriers in service industries.

59. J. Bradford Jensen, "New Questions, Answers for Globalization," Georgetown Business, Spring 2011, available at http://msbmedia.georgetown.edu/new-questions-answers-for-globalization.

60. For evidence that U.S. technological superiority is eroding, see Atkinson and Wial, "Boosting Productivity."

61. Data from Democratic Leadership Council, Trade Facts, June 2010, available at www.dlc.org/ndol_ci.cfm?kaid=108&subid=900003&contentid=255165.

62. Our analysis of United Nations population projections presented in National Science Foundation, *Science and Engineering Indicators 2010* (Arlington, VA: National Science Foundation, 2010), Appendix table 2-42, shows that the population aged 20-24 years (an indicator of the potential size of the foreign student population) in major regions of the world other than the United States is projected to fall from about 411,000 in 2010 to about 407,000 in 2015 and remain at about 407,000 in 2010. In contrast, it rose from about 349,000 in 2000 to about 411,000 in 2010.

63. This is implied by data presented in Andrew B. Bernard and others, "Firms in International Trade," *Journal of Economic Perspectives* 21 (2007): 105-130.

64. Andrew B. Bernard and J. Bradford Jensen, "Why Some Firms Export," *Review of Economics and Statistics* 86 (2004): 561-569.

65. Bernard and Jensen, "Why Some Firms Export." For a description of the Manufacturing Extension Partnership Program, see Atkinson and Wial, "Boosting Productivity," and Helper, "High Road". For evidence if its effectiveness in raising productivity in client firms, see Ronald S. Jarmin, "Evaluating the Impact of Manufacturing Extension on Productivity Growth," *Journal of Policy Analysis and Management* 18 (1999): 99-119; Nexus Associates, Inc., "The Pennsylvania Industrial Resource Centers: Assessing the Record and Charting the Future," October 1999; Eric S. Oldsman and Christopher R. Heye, "The Impact of the New York Manufacturing Extension Program: A Quasi-Experiment," in *Manufacturing Modernization: Learning from Evaluation Practices and Results*, edited by Philip Shapira and Jan Youtie (Atlanta: School of Public Policy and Economic Development Institute, Georgia Institute of Technology, 1997).

66. Paul Davidson, "Some Manufacturing Heads Back to U.S.," *USA Today*, August 6, 2010, available at http://www.usatoday.com/money/economy/2010-08-06-manufacturing04_CV_N.htm.

67. Ibid.

68. Ibid.

69. Harold Sirkin, Michael Zinser and Douglas Hohner, "Made in America, Again: Why Manufacturing Will Return to the U.S" (Boston: Boston Consulting Group, 2011), pp.7-9. It should be noted that Boston Consulting Group has not released the methodology for this report, so we cannot fully assess its analysis. The estimates of Chinese wage growth provided in the text, presented in terms of U.S. dollars, incorporate the recent small increase in the value of the Chinese yuan. According to our analysis of Federal Reserve Board exchange rate data, the U.S.-China exchange rate was between 6.8 and 6.9 yuan per dollar for nearly all the period June 2008-June 2010 and then rose gradually to 6.45 yuan per dollar by July 2011. According to our analysis of data presented in Judith Banister and George Cook, "China's Employment and Compensation Costs in Manufacturing through 2008," *Monthly Labor Review* 134, no. 3 (March 2011):39-52, average hourly compensation in Chinese manufacturing (measured in yuan to separate the impact of domestic wage growth from that of exchange rate movements) rose by about 36 percent from 2002 through 2006 and by about 18 percent from 2007 to 2008. Therefore, we do not need to rely entirely on the Boston Consulting Group estimates to support the assertion that wages in China rose in recent years.

70. Authors' analysis of Bureau of Labor Statistics' Current Employment Statistics data. The inflation-adjusted hourly wage in U.S. durable goods manufacturing peaked at $11.50 (in 1982-84 dollars) and fell continuously to $11.15 in September 2011. For a variety of reasons, including the fact that it comes from a different data source, this average wage would not be comparable to the average weekly or hourly wage estimates presented elsewhere in this report even if it were expressed in 2011 dollars.

71. Sirkin, Zinser and Hohner, "Made in America."

72. Ibid.

73. John Ferreira and Mike Heilala, "Manufacturing's Secret Shift: Gaining Competitive Advantage by Getting Closer to the Customer" (n.p.: Accenture, 2011).

74. Ibid.

75. Timothy Aeppel, "U.S. Shoe Factory Finds Supplies Are Achilles' Heel," *Wall Street Journal*, March 3, 2008.

76. Shih, "The U.S. Can't Manufacture."

77. Authors' analysis of U.S. International Trade Commission (USITC) data for 2010. The data are not adjusted in any way for the purpose of this calculation. The trade deficit in transportation equipment comes primarily from autos and auto parts.

78. However, so did motor vehicles and parts, wood products, and petroleum and coal products. Motor vehicles and parts and machinery had by far the greatest dollar improvements in their trade balances (even though auto parts by itself did not improve its trade balance).

79. Trade balances also deteriorated substantially in electrical equipment/appliances/components and apparel.

80. Mark Muro, Jonathan Rothwell, and Devashree Saha, *Sizing the Clean Economy: A National and Regional Green Jobs Assessment* (Washington: Brookings Institution, 2011).

81. Ibid.

82. George Sterzinger, "Building Energizing Prosperity: Renewable Energy and Re-industrialization" (Washington: Economic Policy Institute, 2008).

83. Daniel M. Kammen, Kamal Kapadia, and Mathias Fripp, "Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?" Renewable and Appropriate Energy Laboratory Report, University of California Berkeley, January 2006, available at http://rael.berkeley.edu/sites/default/files/old-site-files/2004/Kammen-Renewable-Jobs-2004.pdf.

84. Authors' analysis based on Robert E. Scott and Brian A. Siu, "Clean Energy Development for a Growing Economy: Employment Impacts of the Clean EDGE Act" (Washington: Economic Policy Institute and Apollo Alliance, 2006), available at www.policymattersohio.org/wp-content/uploads/2011/10/clean_edge_2006.pdf.

85. Authors' analysis of U.S. Green Buildings Council data and input-output analysis by Heidi Garrett-Peltier, "Employment Estimates for Energy Efficiency Retrofits of Commercial Buildings," Better Buildings Initiative, June 2011, available at www.usgbc.org/ShowFile.aspx?DocumentID=9531. We assume jobs created by retrofit investments will last one year only and, therefore, divide employment figures by ten to estimate the number of jobs a ten year retrofit initiative would support. We also estimate the comparative size of commercial and residential energy consumption using the U.S. Department of Energy Buildings Energy Data Book, available at http://buildingsdatabook.eren.doe.gov/ChapterIntro1.aspx.

86. Susan Helper, "Renewing U.S. Manufacturing: Promoting a High-Road Strategy" (Washington: Economic Policy Institute, 2008).

87. The simple correlation across NAICS three-digit manufacturing industries between the 2001-2009 percent change in jobs and the 2001 average wage was 0.55, while the simple correlation between job change and 2007 value per ton was -0.19. The estimated regression for the relationship between 2001-2009 percent job change, 2001 average wage (in thousands of dollars), and 2007 value per ton (in hundreds of thousands of dollars), with standard errors in parentheses) is:

$$\text{Job Change} = \underset{(0.093)}{-0.637} + \underset{(0.12)}{0.467}\ \text{Average Wage} - \underset{(0.182)}{0.437}\ \text{Value/ton},\ R^2=0.475.$$

88. These are all NAICS six-digit industries.

89. Some have attributed the recent job growth in the auto industry to wage cuts agreed to by the United Auto workers beginning in 2007. There are many problems with this argument. First, only about 10 percent of the cost of a car was due to UAW labor in 2008; the percentage is even lower now. The main cause of troubles among the "Detroit Three" automakers was not that costs were too high, but rather that consumers were willing to pay a $2,000–3,000 price premium to buy a Honda or Toyota. The improved performance recently can be attributed largely to reduced dysfunction in product design and purchasing, implemented by the new management at GM and Chrysler. Susan Helper, "Challenge and Opportunity in the U.S. Auto Industry: The Key Role of Suppliers," *Journal of Industrial and Business Economics* 38 (2011): 51-67.

90. Our analysis of Bureau of Labor Statistics Current Employment Statistics data shows that the number of durable manufacturing jobs increased by 4.7 percent in the 21 months from December 2009 through September 2011. This compares with an 11.1 percent increase from December 1982 through September 1984 and a 5.2 percent increase from July 1993 through April 1995. After the 2001 recession, the number of durable manufacturing jobs grew by only 1.1 percent from October 2003 through July 2005.

91. See Box 3 of this report for evidence of manufacturers reassessing offshoring.

92. Already there are 700,000 manufacturing workers in the "clean economy"; manufacturing accounts for 26 percent of the jobs in this sector. Muro, Rothwell, and Saha, *Sizing*. Economist Robert Pollin and co-authors have found that, compared to the fossil-fuel sector, renewable energy and

energy efficiency programs both create more U.S. jobs and have higher average pay. This is possible largely because the fuel input (wind, sun) is free, compared to resource rents paid for oil and coal. See Robert Pollin, James Heintz, and Heidi Garrett-Peltier, "The Economic Benefits of Investing in Clean Energy" (Washington: Center for American Progress, 2009).

93. To avoid giving manufacturers an incentive to offshore production and thereby negate the carbon-reducing effect of the tax, the tax would need to include a fee for importing goods from countries with lower carbon charges.

94. The net effect on domestic jobs and wages of a move toward renewable energy would be strongly positive. See Pollin, Heintz, and Garrett-Peltier, "Economic Benefits."

95. A fifth industry, petroleum and coal products, does well on many measures, but has very poor environmental performance.

96. See Helper and others, "The U.S. Auto Supply Chain."

97. High-wage firms are defined as those paying higher wages than 90 percent of all firms in the industry and lower wages than 10 percent. Middle-wage firms are those that pay more than 50 percent of all firms and less than 50 percent. Low-wage firms are those that pay more than 10 percent of all firms and less than 90 percent.

98. Bernard and others, "firms." Authors' analysis of data in Chad Syverson.

99. "Product Substitutability and Productivity Dispersion," *Review of Economics and Statistics* 86 (2004): 534-550. We define high-productivity plants as those whose productivity is higher than that of 90 percent of all plants in the same industry and lower than that of 10 percent. Low-productivity plants are those whose productivity is higher than that of 10 percent of all plants in the same industry and lower than that of 90 percent.

100. Daniel Luria and Joel Rogers, "Manufacturing, Regional Prosperity, and Public Policy," in *Retooling for Growth*, edited by Richard M. McGahey and Jennifer S. Vey (Washington: Brookings Institution Press, 2008), pp. 249-274.

101. Authors' analysis of unpublished Michigan Manufacturing Technology Center Performance Benchmarking Survey data supplied by Dan Luria.

102. To explore these ideas more systematically we performed a cluster analysis. Consistent with the discussion above, we found one group of firms (accounting for about 20 percent of the sample) that had adopted all of the practices discussed above); this group had the highest productivity. A second group of firms (about 40 percent of the sample) had very few of the practices and had the lowest productivity.

103. We define productivity as value added per worker and calculate it by subtracting a firm's purchased inputs from its sales and dividing by the number of employees.

104. Daron Acemoglu, "Good Jobs versus Bad Jobs," *Journal of Labor Economics* 19 (2001),: 1-21.

105. Daniel D. Luria, "Why Markets Tolerate Mediocre Manufacturing," *Challenge*, July-August 1996, and unpublished annual data from Michigan Manufacturing Technology Center's Performance Benchmarking Survey, 1993-2009; Ann Bartel, Casey Ichniowski, and Kathryn Shaw, "How Does Information Technology Affect Productivity? Plant-Level Comparisons of Product Innovation, Process Improvement, and Worker Skills," Quarterly Journal of Economics 122 (2007): 1721-1758; Helper, "High Road"; Susan Helper, John Paul MacDuffie, and Charles F. Sabel, "Pragmatic Collaborations: Advancing Knowledge While Controlling Opportunism," Industrial and Corporate Change 9 (2000): 443–483; Daron Acemoglu and Jörn-Steffen Pischke, "The Structure of Wages and Investment in General Training," *Journal of Political Economy* 107 (1999): 539-572.

106. For a variety of reasons, including the fact that it comes from a different data source, this average wage is not comparable to the average weekly or hourly wage estimates presented elsewhere in this report.

107. Steven Pearlstein, "Wage Cuts Hurt, but They May Be the Only Way to Get Americans Back to Work," *Washington Post*, Oct 12, 2010, available at www.washingtonpost.com/wp-dyn/content/article/2010/10/12/AR2010101206121.html.

108. Manufacturing employment, as used here, differs from the number of manufacturing jobs because it measures the number of people whose main job was in manufacturing. People with multiple jobs are counted only once. In addition, manufacturing jobs and manufacturing employment are derived from different surveys and are not directly comparable. Data on manufacturing employment are comparable across countries while data on manufacturing jobs are not.

109. Authors' analysis of data in Bureau of Labor Statistics, "International Comparisons of Annual Labor Force Statistics, Adjusted to U.S. Concepts, 10 Countries,

1970-2010," table 2-4. Because many of the foreign data series have series breaks in some year between 2000 and 2010, we also compared the United States and United Kingdom to each foreign country over the time period(s) for which employment data were strictly comparable. In all cases, the United States and United Kingdom had larger percentage losses of manufacturing employment than the other eight countries shown.

110. Canada and Japan lost smaller percentages of their manufacturing employment between 2000 and 2010 then the United States but their manufacturing wages were lower.

111. Atkinson and Wial, "Boosting Productivity."

112. Organisation for Economic Co-operation and Development, *OECD Science, Technology, and Industry Scoreboard 2011*, available at http://www.oecd-ilibrary.org/sites/sti_scoreboard-2011-en/02/05/index.html?contentType=&itemId=/content/chapter/sti_scoreboard-2011-16-en&containerItemId=/content/serial/20725345&accessItemIds=/content/book/sti_scoreboard-2011-en&mimeType=text/html.

113. Organisation for Economic Co-operation and Development, Goods trade balance data, available at http://www.oecd-ilibrary.org/trade/goods-trade-balance_20743920-table2.

114. Robert D. Atkinson and others, *Rising Tigers, Sleeping Giant* (Washington: breakthrough Institute and Information Technology and Innovation Foundation, 2011).

115. David G. Victor and Kassia Yanosek, "The Crisis in Clean Energy," *Foreign Affairs* 90 (July/August 2011), available at http://ilar.ucsd.edu/assets/001/502035.pdf.

116. Atkinson and Wial, "Boosting Productivity."

117. Robert D. Atkinson and Luke A. Stewart, "University Research Funding: The United States Is Behind and Falling" (Washington: Information Technology and Innovation Foundation, 2011).

118. Helper and Wial, "Accelerating Advanced Manufacturing."

119. Peter Capelli, "Why Companies Aren't Getting the Employees They Need," *Wall Street Journal*, October 24, 2011, available at http://online.wsj.com/article/SB10001424052970204422404576596630897409182.html.

120. Atkinson and Wial, "Boosting Productivity."

121. Findings from interviews with U.S. automotive suppliers conducted as part of Case Western Reserve University's study of automotive suppliers. Susan Helper and others, primary interviews, Driving Change Project, 2010-2011.

122. Helper and Wial, "Strengthening American Manufacturing."

123. Atkinson and Wial, "Boosting Productivity."

124. Philip Mattera and others, "Money for Something: Job Creation and Job Quality Standards in State Economic Development Subsidy Programs" (Washington: Good Jobs First, 2011), available at www.goodjobsfirst.org/sites/default/files/docs/pdf/moneyforsomething.pdf.

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