One

Competing—and Winning—in a Global Economy

The following discussion sets out a framework for understanding the challenges identified by U.S. manufacturers. This chapter highlights the critical contribution manufacturing makes to the U.S. economy and details the many underlying strengths of the manufacturing sector.

The manufacturing sector's rapidly rising productivity is its greatest strength and a major contributor to the growth of the U.S. economy. Higher productivity offers multiple benefits: stronger competitiveness in manufacturing and other sectors of the economy, higher real wages, and a rising standard of living. That same productivity growth, however, has also been largely responsible for the gradual decline in employment in manufacturing: manufacturing employment has declined even as U.S. manufacturers have become more efficient both in absolute terms and relative to other sectors in the economy.

The manufacturing sector's overall performance in the past 25 years has been very strong, despite difficult periods of adjustment through the 1970s and 1980s. It remained strong despite shocks to the world economy, including those in some of the strongest U.S. export markets during the Asian financial crisis of 1997.

However, the manufacturing sector was hit by a particularly harsh recession in mid-2000, before the overall economy took a downward turn. Although rapid monetary and fiscal responses kept the recession in check, the cyclical changes flowing from the recession hit the manufacturing sector with unusual force.

In fact, the general economic downturn that first appeared in the manufacturing sector in mid-2000 may have masked the far more powerful underlying structural changes affecting manufacturing. With rapid advancements in technology, lower barriers to trade, and the entry of significant new competitors into global markets, the past five to 10 years have been marked by rapid change for America's manufacturers, even as they continue to adapt to the global market.

Importance of Manufacturing to the Economy

Manufacturing is crucial to the U.S. economy. Every individual and industry depends on manufactured goods. In addition, innovations and productivity gains in the manufacturing sector provide benefits far beyond the products themselves.

There is no dispute over the significant contribution that manufacturing

makes to the U.S. economy and to America's standard of living. The sector continues to account for 14 percent of U.S. GDP and 11 percent of total U.S. employment.

Those statistics, however, do not adequately convey the importance of the manufacturing sector to the U.S. economy and to America's future. Manufacturing is an integral part of a web of inter-industry relationships that create a stronger economy. Manufacturing sells goods to other sectors in the economy and, in turn, buys products and services from them.

Manufacturing spurs demand for everything from raw materials to intermediate components to software to financial, legal, health, accounting, transportation, and other services in the course of doing business. According to the Bureau of Economic Analysis, every $1 of final demand spent for a manufactured good generates $0.55 of GDP in the manufacturing sector and $0.45 of GDP in non-manufacturing sectors.[1]

The automotive sector provides a good example. The production of automobiles stimulates the demand for everything from raw materials in the form of coal and iron to manufactured goods in the form of robots to the purchase of services in the form of health insurance for the automobile companies' employees.

A healthy manufacturing sector is critical to America's economic future for other reasons as well—innovation and productivity.[2] Innovation holds the key to rising productivity, and productivity gains are the key to both economic growth and a rising standard of living.[3] As one leading economist put it:

A nation's standard of living in the long term depends on its ability to attain a high and rising level of productivity in the industries in which its firms compete.[4]

Rising productivity is the key to maintaining U.S. competitiveness in manufacturing, but the benefits of rising manufacturing productivity extend to the economy as a whole. For example, improvements in cotton harvesting equipment, manufactured in the Midwest, help improve the productivity of cotton growers in California and Texas. And expanding the power of computers makes on-line banking and other financial services possible.

A recent study by the National Institute of Standards and Technology reinforces how the benefits of improved manufacturing productivity extend to other sectors in the economy. The NIST study detailed the service sector's reliance on U.S. manufacturers for the goods and technology that spur service sector growth. It emphasized "the substantial dependency of services on manufacturing firms for technology" and the "critical role" manufacturing plays in stimulating growth in the services sector, which now makes up more than 70 percent of the U.S. economy.[5]

From the perspective of the average American worker, rising productivity translates into higher real wages and a broader range of higher-quality, lower-cost goods, meaning each additional dollar earned goes further. This makes it is easier to buy a home, save for a child's college education, or set aside money for retirement.

The manufacturing sector has generated many of the innovations that have led to significant productivity gains over the past 25 years in manufacturing and throughout the economy. Increases in manufacturing productivity have consistently outpaced other sectors of the U.S. economy. From 1977 to 2002, productivity in the overall economy increased 53 percent, while manufacturing sector productivity rose 109 percent. The greater than 50-percent increase in overall productivity represents a tremendous gain in the U.S. standard of living, and the more than 100-percent increase in manufacturing productivity is a remarkable achievement. As Figure 1 reflects, labor productivity in manufacturing has doubled since 1977. The rate of change has increased

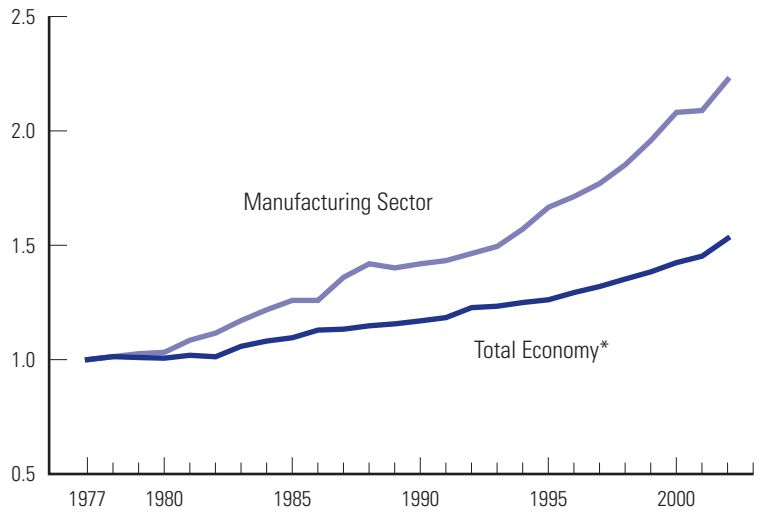
over time, with productivity growing faster (14.2 percent) in the past two and a half years, since the beginning of the last recession, than in any two-and-a-half-year period in the past 50 years.

Further, U.S. productivity strongly exceeds that of America's principal trading partners (Figure 2). The United States leads all countries in the absolute level of labor productivity, both per hour and per employee. This position has enabled the United States to maintain its labor cost advantage over these trade competitors despite the higher wages and benefits paid to American workers. The recently stronger performance of U.S. manufacturing in raising its productivity represents one of the causes for optimism for the sector's ability to adjust to rising levels of competition at home and abroad. The ability to raise productivity, even in the midst of recession and recovery, reflects that U.S. manufacturers have made changes in their operations and production methods to put themselves in a stronger position than manufacturers in other industrialized nations.

The growth in productivity has also had a profound effect on the U.S. standard of living. The 31-percent productivity advantage of the U.S. economy over OECD members accounts for three-quarters of the per capita income difference.[6]

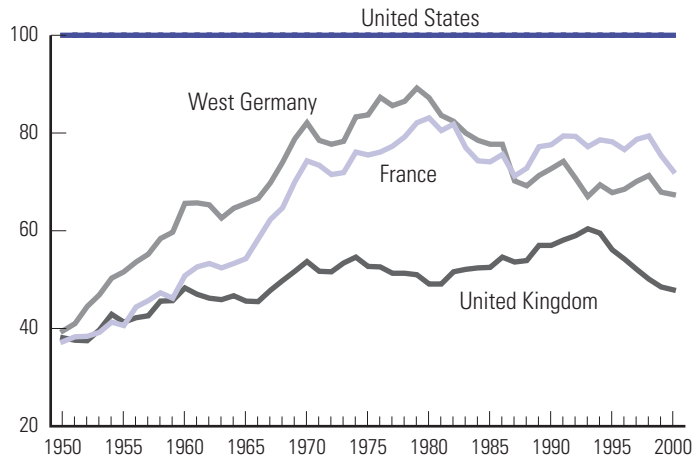
One important vehicle for the rising productivity in manufacturing has been technological innovation. In manufacturing, technological innovation comes in two forms. First, new inventions provide a leap forward in technology. Consider the first integrated circuits and the astonishing array of products that are directly related to its development. Many of those inventions derive from large investments in research and development in the manufacturing sector: manufacturing firms fund 60 percent of the $193 billion that the U.S. private sector invests annually in R&D.[7] Those technologies are absorbed by the much larger service sector and drive

Figure 1. **Productivity in Manufacturing and the Total U.S. Economy, 1977–2002**



* Excludes government and agricultural sectors.
Index: 1977 = 1.0
Source: U.S. Department of Labor, Bureau of Labor Statistics.

Figure 2. **Per-Capita Manufacturing Output in Western Europe Relative to the United States, 1950–2000**

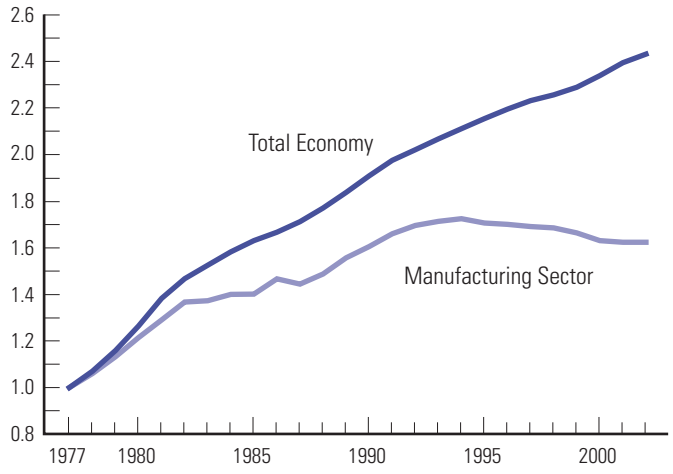


Index: U.S. level = 100
Note: "West Germany" data are for West Germany throughout, even after 1990.
Source: U.S. Department of Labor, Bureau of Labor Statistics; Groningen Growth and Development Center, International Comparisons of Output and Productivity by Industry.

the increasing rates of innovation and productivity growth in that sector.

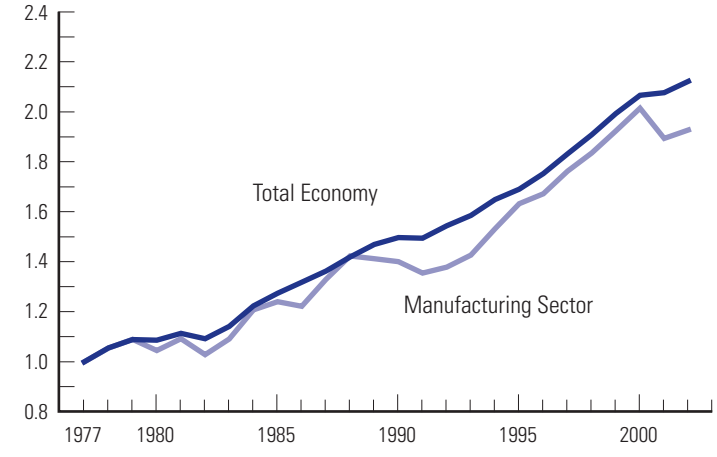
The other form of innovation comes from the steady improvement in products and manufacturing processes within major technology life cycles. Such improvement involves many less dramatic innovations, but collectively these innovations have a significant effect. For example, incremental improvements in the ability to etch a higher number of functions on a microprocessor or to multiply the number of calls a fiber-optic cable can transmit have a remarkable effect over time.[8]

Figure 3. **Prices in Manufacturing and the Total U.S. Economy, 1977–2002**



Index: 1977 = 1.0
Sources: Total economy: U.S. Department of Commerce, Bureau of Economic Analysis; manufacturing sector: U.S. Department of Labor, Bureau of Labor Statistics.

Figure 4. **Output in Manufacturing and the Total U.S. Economy, 1977–2002**



Index: 1977 = 1.0
Source: U.S. Department of Commerce, Bureau of Economic Analysis.

Both major and incremental innovations improve the competitiveness of the manufacturing sector and the U.S. economy as a whole. Because productivity has risen faster in manufacturing than in the services sector, prices of manufactured goods have risen more slowly than prices of services. At times, manufactured goods prices have even declined. That pricing pressure helps keep production costs in check for both the manufacturing sector and other areas of the economy.

In the past 25 years, prices in the overall economy have increased more than 140 percent, while prices in manufacturing have increased only slightly more than 60 percent (Figure 3). That also explains why manufacturing's share of nominal private output has declined from around 27 percent in 1977 to around 16 percent at present, even while the sector's contribution to real private output growth has remained roughly the same since 1977.

Real manufacturing output, adjusted for changes in prices, provides the best representation of manufacturing output over the past 25 years relative to the rest of the economy. Real manufacturing output since 1977 has grown nearly as fast as real output of the private economy as a whole (Figure 4).

Another way of measuring the similarity between manufacturing's growth in real terms and that of the broader economy is to look at the sector's contribution to the growth of real private output. Measured that way, the manufacturing sector's contribution has remained roughly steady at 0.6 percentage points for each 10-year

average annually from the 1977–1987 period to the most recent 1992–2002 period (Figure 5).

Compensation and Employment

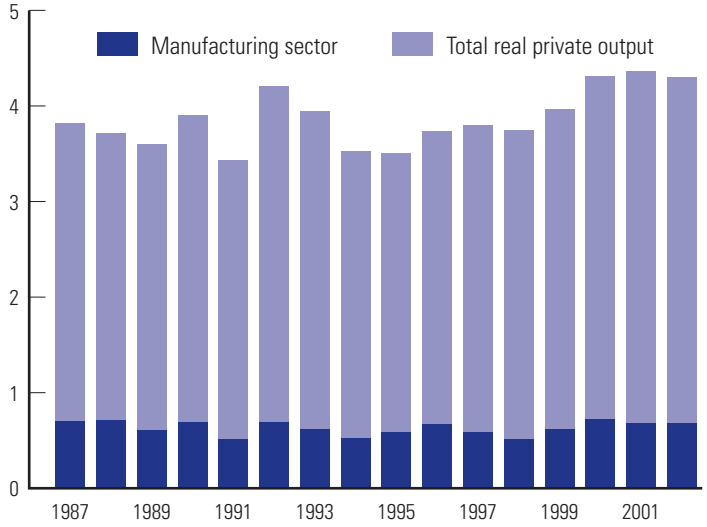
Historically, the manufacturing sector has had the reputation of providing a way for blue-collar workers to find good-paying jobs. Even today, the average hourly total compensation of production workers in manufacturing is higher than the average in all other sectors.

However, manufacturing's advantage in total compensation is based on benefits, rather than higher hourly wages. Average hourly earnings of production workers since 1967, when measured on an inflation-adjusted basis, suggest that manufacturing as a sector has offered an average, rather than high, hourly wage. There are, of course, specific sectors such as autos and steel that have offered wages far above the average, but these are balanced by others that have offered below average wages. In fact, the average hourly earnings in the wholesale trade, finance, and service sectors have surpassed those in manufacturing over the past 10 years; only retail trade remains lower.

The advantage of working in the manufacturing sector has derived, instead, from the higher level of average benefits received ($8.89 per hour for manufacturing versus $5.94 for non-manufacturing). Manufacturers contribute an average of $0.81 per hour more for health insurance, $0.66 more for overtime and supplemental pay, $0.62 more for leave, $0.29 more for retirement, and $0.34 more for other benefits (Figure 6).[9]

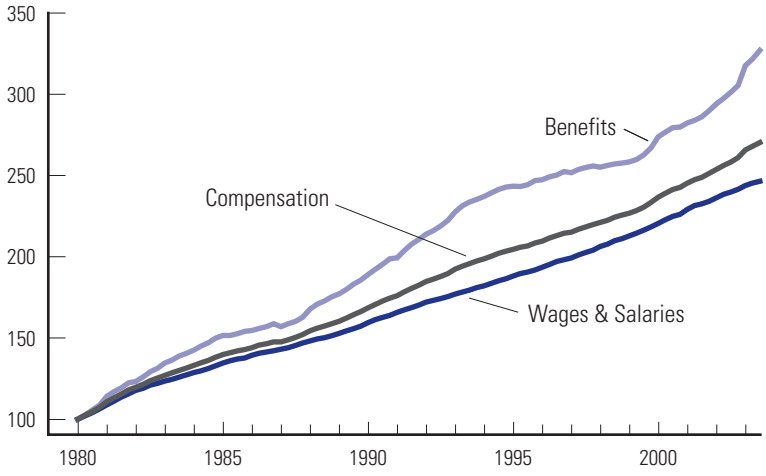
Because productivity gains in manufacturing have outstripped the growth in demand for manufactured goods, manufacturing employment has been falling for the past three decades. Manufacturing employment was significantly lower in 2002 than in 1977, falling from 22 percent of the non-farm economy to under 12 percent. Partial data for 2003 indicate

Figure 5. **Manufacturing as a Percentage of Average U.S. Private GDP Growth, 1987–2002** (Ten-Year Averages)



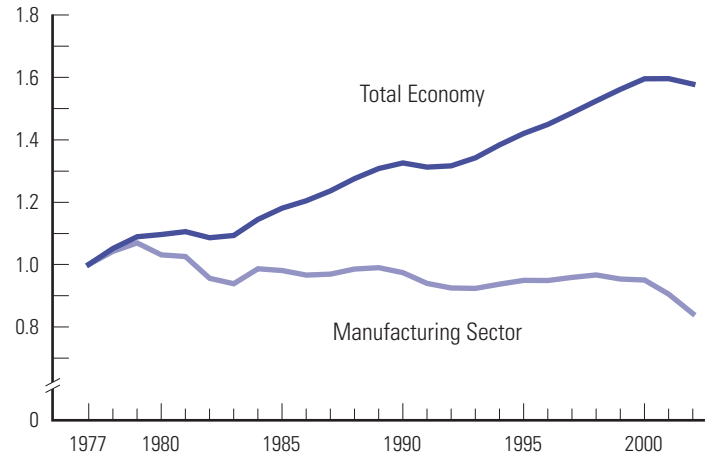
Note: "Total real private output" is the same as total real U.S. private GDP—that is , GDP minus the government sector. The top bars show the 10-year growth of private GDP, annualized to single-year averages. The bottom bars show 10-year moving averages: for a given year, contribution to private GDP growth by the manufacturing sector for that year is averaged with the previous nine years.
Source: U.S. Department of Commerce, Bureau of Economic Analysis.

Figure 6. **Employment Cost Index, 1980–2002**

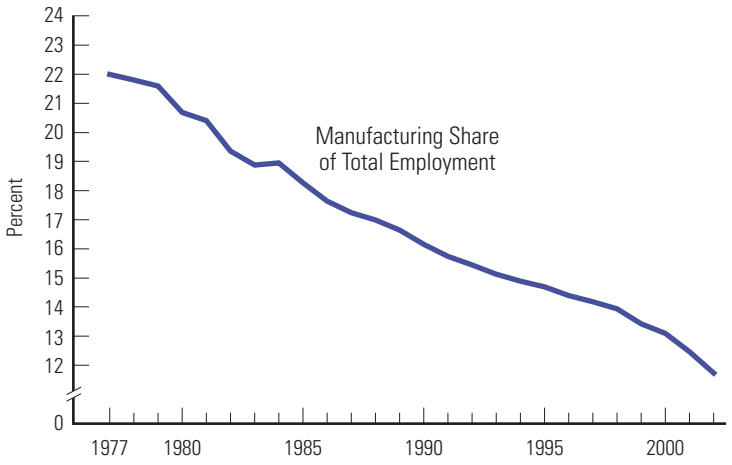


Index: 1980 = 100
Source: U.S. Department of Labor, Bureau of Labor Statistics.

Figure 7. **Total Employment Growth and Manufacturing Employment Decline, 1977–2002**



Index: 1977 = 1.0
Source: U.S. Department of Labor, Bureau of Labor Statistics.



Source: U.S. Department of Labor, Bureau of Labor Statistics.

that the share has fallen further to about 11 percent (Figure 7).

Given that manufacturing represents a stable part of the economy while enjoying outsized productivity gains, the gradual decline in manufacturing employment is not surprising. Expressed another way, given the more rapid gains in labor productivity, manufacturing's share of total output would need to increase dramatically to maintain a given level of employment.

While the number of U.S. manufacturing jobs has fallen since 1979, other advanced economies have experienced the same trend. In the 1990s, manufacturing's share of employment fell at least as fast, if not faster, in Western Europe than in the United States (Figure 8).

On average, U.S. manufacturing employment has fallen 0.4 percent annually over the past 35 years. But that average rate of decline masks large fluctuations. Manufacturing employment rises and falls sharply in each business cycle. With each recession, manufacturing employment falls slightly lower than the previous trough. When the business cycle turns up and manufacturing firms begin hiring again, manufacturing employment rises, but it does not quite reach its previous peak.

These trends provide a useful transition to discuss the more recent developments in manufacturing.

Cyclical Effects of Recession and Recovery

After seeing prospects improve for more than a decade, American manufacturers have, in the past five years, faced harsh economic conditions. Recessions are typically hard in manufacturing. Of the eight recessions since 1950, real GDP has declined, on average, about 2 percent, whereas manufacturing output has declined 7 percent.

By the standard of overall output, the recession of 2001 was relatively mild;

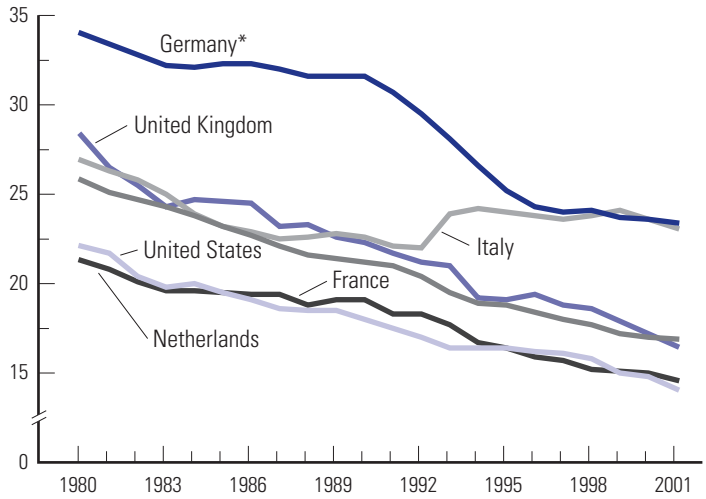
however, it hit the manufacturing sector particularly hard. Manufacturing output declined about 6 percent from the fourth quarter of 2000 to the third quarter of 2001, over which time real GDP fell 0.5 percent.

What has been striking about the most recent recession in manufacturing, however, was not the sharp drop in output, but the slow pace of recovery. In all but the most recent recession since World War II, manufacturing output has increased nearly 15 percent in the first two years of economic recovery. However, over the past two years, a period during which GDP rose nearly 6 percent, manufacturing output declined slightly (Figure 9). Total manufacturing production is still down some 4 percent below its previous peak of mid-2000.

The recession and the slow pace of recovery in manufacturing have been particularly hard on workers in manufacturing. Since the onset of the manufacturing employment downturn, the sector has lost 2.6 million jobs, while employment in other sectors has been relatively stable. In the third quarter of 2003, manufacturing employment remained 15 percent lower than in the period immediately before the recession. Perhaps more significantly, employment in manufacturing has fallen 8 percent since the recovery began. This decline was widespread across all manufacturing sectors (Table 1).

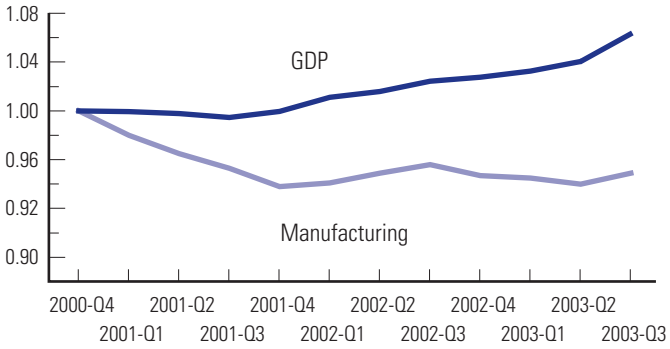
There were several features of the recent recession that made its effect on the manufacturing sector more pronounced. First, there was a significant retrenchment in business investment in technology following a surge in such investment throughout the preceeding decade. It is generally accepted that the high-tech sector spurred the economy in the late 1990s. High-tech production peaked, however, in late 2000 (Figure 10). Output in the sector declined 12 percent by the summer of 2001, decreasing considerably

Figure 8. **Manufacturing Employment as a Percent of Total Civilian Employment in Europe and the United States, 1980–2001**



* "Germany" data are for West Germany through 1990, and for unified Germany thereafter.
Source: U.S. Department of Labor, Bureau of Labor Statistics.

Figure 9. **GDP and Manufacturing Output, 2000–2003**



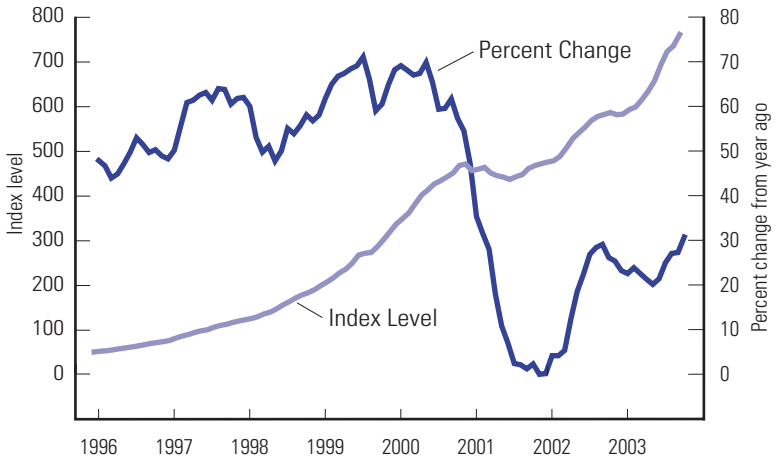
Index: Fourth quarter 2000 = 1.00
Sources: GDP: U.S. Department of Commerce, Bureau of Economic Analysis; manufacturing output: Board of Governors of the Federal Reserve System.

Table 1. **Net Change in Manufacturing Employment, Fourth Quarter 2000 to Third Quarter 2003**

	Percent	Number of Jobs
Total Manufacturing	**-15.1**	**-2,599,000**
Food	-1.8	-29,000
Beverage and Tobacco	-6.7	-14,000
Textile Mills	-29.5	-109,000
Textile Product Mills	-15.8	-34,000
Apparel	-37.4	-178,000
Leather and Products	-34.1	-22,000
Wood Products	-9.6	-57,000
Paper	-12.3	-74,000
Printing	-14.0	-113,000
Petroleum/Coal Products	-3.9	-5,000
Chemicals	-6.3	-62,000
Plastics/Rubber	-11.9	-112,000
Nonmetallic Minerals	-9.4	-52,000
Primary Metals	-22.7	-140,000
Fabricated Metals	-16.6	-293,000
Machinery	-19.6	-285,000
Computers and Electronics	-25.1	-467,000
Electrical Equipment	-21.3	-125,000
Transportation	-12.8	-260,000
Furniture	-15.5	-105,000
Miscellaneous	-8.6	-63,000

Source: U.S. Department of Labor, Bureau of Labor Statistics.

Figure 10. **High-Tech Industrial Production, 1996–2003**



Notes: High-tech industries are defined for this analysis as computers, communication equipment, and semiconductors.
Source: Board of Governors of the Federal Reserve System.

further than the average for the manufacturing sector as a whole.

The drop-off in high-tech spending that led the decline affected the high-tech sector worldwide. Data on global semiconductor sales, for example, indicate a sizable drop beginning in late 2000 and continuing for the next year as businesses spent considerably less on communications and computing technology (Figure 11).

Two manufacturing sectors that experienced among the largest percentage job declines were precisely those industries most affected by the decline in high-tech spending. Employment in computers and electronics fell 24 percent from the fourth quarter of 2000 to the third quarter of 2003, and the decline in employment in electrical equipment was of similar magnitude—23 percent. Both decreases were larger than the 18-percent average for manufacturing as a whole.

The second feature of the recession that deserves attention was the sharp drop in inventories that accompanied the downturn. Inventory imbalances are typical for recessionary periods. Demand falls, and excess inventory is left on the shelves. Businesses respond by cutting back orders, shipments, and production until demand returns.

In the most recent recession, businesses reacted to a modest increase in inventory-to-sales ratios during 2000 by cutting back production in 2001 to get supply under control. The extent of the resulting relatively drastic inventory liquidation was much more severe in the 2001 recession than it was in the 1990–1991 recession.

The third feature of the recession worth noting is the uncertainty caused by the events of September 11, 2001, which depressed investment and demand. In addition to the direct effects on demand for manufactured goods, the decline in the demand for services such as tourism had subsequent effects on other manufacturing sectors such as autos and aircraft.

A fourth feature of the recession is the extent to which slower growth at home was compounded by the effects of slower growth abroad, particularly the dramatic drop in U.S. manufacturing exports to our principal export markets. Stronger growth abroad helps cushion the effects of recession at home.

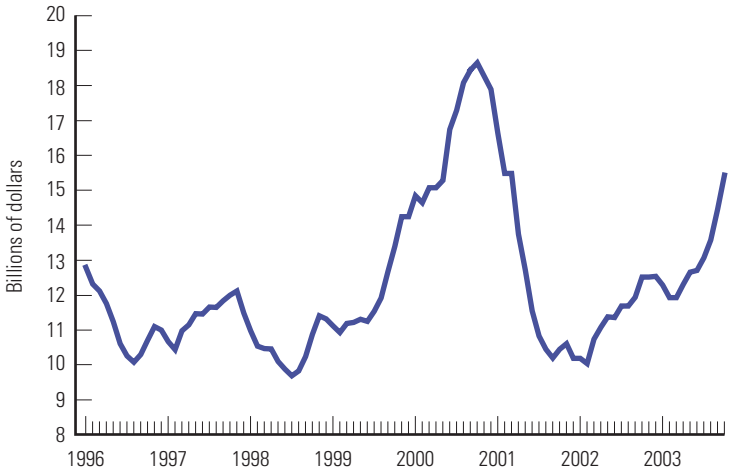
Unfortunately, although they have shown recent signs of growth, both Europe and Japan have grown considerably slower than the United States since the beginning of the recovery. Slower growth among the industrial economies has magnified the effect of slower growth in emerging economies in Asia since the onset of the Asian financial crisis in mid-1997. Although several Asian economies have recovered, the region's growth, with the principal exception of China, has yet to approach the levels reached before to the financial crisis.

Continued slow economic growth abroad produces less demand for U.S. manufactured goods than would otherwise be the case. Figure 12 covers a period that includes the last three U.S. recessions: in 1982, 1991, and 2001. The pattern of the most recent recession resembles that of the 1982 recession, which was marked by stagnation among America's major trading partners.

What the trend lines reflect is that the U.S. economy in general, and the manufacturing sector in particular, received little support from growth among major U.S. trading partners over the past two years.

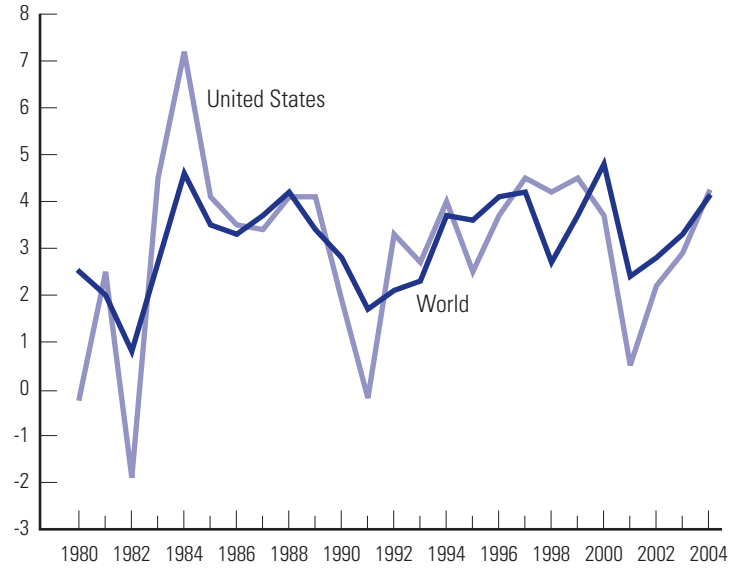
However, the U.S. economy as a whole has responded to both monetary and fiscal stimulus in the past year. The economy grew at an annual rate of 8.2 percent in the third quarter of 2003, which translates into stronger demand for all goods and services, including manufactures. In addition, there are signs of growing strength in a number of markets abroad. That stronger growth, combined with the continued competitiveness of the

Figure 11. **Worldwide Semiconductor Sales, 1996–2003**
(Billions of Dollars)



Notes: Data are based on a three-month moving average, wherein each month's sales figure is an average of its total sales and those of the subsequent two months. Data for 2003 are through October.
Source: Semiconductor Industry Association.

Figure 12. **Economic Growth: History and Forecast, 1980–2004**
(Percent Change)



Sources: World: International Monetary Fund; United States: U.S. Department of Commerce, Bureau of Economic Analysis.

U.S economy, has improved the prospects for exports of U.S. manufactured goods.

The manufacturing sector has recently begun to participate in the broader recovery under way in the U.S. economy. The Institute of Supply Management's Purchasing Manager's Index has remained above 50 (indicating continuing growth in future orders for manufactured goods) since August 2003.

Furthermore, rising productivity remains a bright light. Since the end of the recession, productivity in manufacturing is up 9.7 percent. Measuring from the period immediately before the recession, productivity is up 14.2 percent.

Those increases in productivity speak to the ability of American manufacturing to meet the competitive challenges and make a contribution to the rising standards of living in the economy. What the manufacturing sector can control—to invent, to innovate, and to combine resources to produce quality merchandise—it does quite well.

Structural Changes Shaping the Competitive Environment

With renewed growth in the U.S. economy, rising production numbers in the manufacturing sector, and significant gains in productivity even in the face of the recent recession, the manufacturing sector is poised for what could be a strong recovery. Nevertheless, the cyclical effects of the recession and the strengthening recovery are only part of the manufacturing story. In some respects, the recent recession has obscured the more fundamental structural changes under way in the manufacturing sector globally.

Over the past two decades, three separate, powerful trends have reshaped the manufacturing sector globally. The first is the revolution in technology that has been under way for two decades, raising productivity in manufacturing and reducing costs worldwide. The second is the significant reduction in barriers to trade, particularly with respect to trade in manufactured goods. The third is the end to political divisions that have segmented markets for more than 70 years and the corresponding emergence of Russia, China, and other countries in the world trading system. Each of these trends has significant implications for U.S. manufacturing, both in the form of new market opportunities as well as stronger competition.

Role of Technology

Global manufacturing has been fundamentally reshaped by the remarkable improvements in computing, communications, and distribution. Each factor, standing alone, would have greatly expanded the opportunities for trade, investment, and global production. Taken in combination, however, the rapid changes in all three influence many of the trends that have most reshaped manufacturing from the shop floor to the loading dock to the final customer. What these factors have also done is raise the bar to compete in today's manufacturing environment.

In 1987, in a review of the book *Manufacturing Matters*, Nobel Prize-winning economist Robert Solow famously observed, "You can see the computer everywhere but in the productivity statistics."[10] In the latter part of the 1990s, however, the evidence of the computer's effect on productivity finally surfaced. Compared with the relatively slow rates of productivity growth experienced between 1973 and 1995, labor productivity grew "roughly 1.2 percentage points [faster] a year from 1995 through 2000, a rise of more than 80 percent" above the previous trend line.[11] Investments in information technology are estimated to account for 60 percent of that increase in productivity.[12]

The dramatic expansion of computing power and its application to an ever greater range of tasks in the business environment is without a doubt the single most powerful technological change

affecting manufacturing today. Moore's Law—that computing power will double every 18 months—still prevails and is likely to continue for some time to come. One useful way to think about the explosion in computing power is the fact that the microchip in today's talking greeting cards contains more computing power than existed worldwide in 1945.[13]

Even skeptics of the contribution of information technology to productivity gains, such as Robert Gordon, generally have conceded its impact on manufacturing.[14] The increase in computing power touches every part of the manufacturing process. It has revolutionized product design by introducing computer-assisted design that allows much of the product development and testing to be done at a far lower cost in a virtual environment. Computing power has revolutionized manufacturing by creating a whole new family of multiple-axis machine tools that offer unmatched precision, quality, and efficiency.

Computers have also made possible most of the revolutions in business processes as well. In the absence of the computing power available today, concepts such as "just-in-time" production and "demand-pull" manufacturing processes could not exist in their current forms.[15] The dramatic increase in computing power has created an ever more powerful tool for developing new products, lowering production costs, raising quality, measuring performance, and managing business.

Communications technologies are essential to running high-performance manufacturing operations. New communications technologies create the ability to manage just-in-time inventories and demand-pull manufacturing. Real-time communication is critical to feeding information back into a system that is designed to yield zero defects. Interoperable communications systems provide opportunities for manufacturers and their customers to collaborate in product development.

Similarly, new communications technologies allow engineers to conduct real-time product development discussions with colleagues around the world. In addition to the videoconferencing capability, communications technologies use operating systems that allow anyone participating in the discussion to manipulate the same computer-generated design on the screen.

The revolution in communications has fundamentally changed the way manufacturers do business. Wireless communication means that a cellular phone and a laptop computer can replace a salesperson's office. Not only does the cellular phone allow for greater contact and consultation with customers about their needs, but it also contains the necessary functions to place an order and begin the manufacturing process directly from the point of sale.

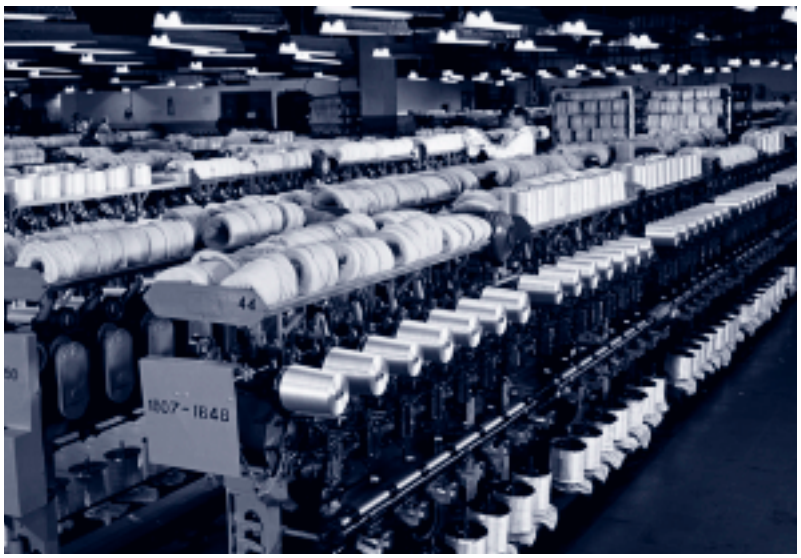
manufacturing has been fundamentally reshaped by the remarkable improvements in computing, communications, and distribution

The communications revolution has also significantly changed the delivery of finished goods to customers. For instance, in trucking, the combination of a global positioning system transmitter and a cellular phone has meant less waste, greater efficiency, and a lower cost to manufacturing customers. New communications devices also ease the distribution of goods by creating an interface with government agencies that may require information for security or regulatory reasons. By reducing the costs of distribution, new communications technologies have reduced the cost of the end products.

The application of technology has also transformed the distribution of manufactured goods and reduced the costs of transportation. Obviously, air travel has contributed much to making the competitive marketplace for manufactured goods a single market. In addition, significant changes in shipping since World War II, such as the rise of containerization and

roll-on/roll-off cargo allow for a smooth transition from container ship to rail to truck and dramatically increase efficiency. Distribution is also aided by new cargo handling facilities operated by express delivery services. For example, this enables computer manufacturers to operate overnight repair facilities and deliver repaired computers to their owners in fewer than 24 hours.

The combination of the trends in computing, communications, and transportation has generated a new service of door-to-door logistics. Logistics has become essential to meet the demands of



the market and has been fundamental in lowering the costs of manufacturing to remain competitive. The competitive environment has been reshaped by such advances, which grew out of post-World War II defense research.[16] The Office of Naval Research funded the research of a number of engineering professors at the nation's premier research institutions. Those professors had been instrumental in solving a wide range of practical technical problems attendant to the war effort during World War II and continued to receive ONR funds after the end of the war in 1945.

The post-World War II investment in R&D paid enormous dividends in the form of new products, new industries, and improved growth and competitiveness of U.S. manufacturing. But, increasingly, it is private industry that is making the investments driving innovation. By 1980, industry had become the lead investor in U.S. R&D activities, investing more than the federal government for the first time. Today, robust private sector investment in R&D outpaces federal R&D funding by a ratio of more than two to one, effectively reversing the ratio that prevailed throughout the Cold War and the space race.

The lesson that the post-World War II revolution in science and engineering in the United States flowed from investments in R&D was not lost on foreign nations. Today, nations everywhere recognize the link between technology, economic growth, and job creation. They are, as a consequence, increasingly establishing research institutes and key technology programs; creating incentives for partnerships among industry, academia, and government; and boosting training for scientists and engineers.

That dynamic is reflected in the sharp decline in the U.S. share of total world R&D spending. Through the 1960s, the U.S. share of global R&D ranged between 60 and 70 percent. Today, by contrast, the U.S. share is 30 percent.

Equally important is the proportion of a nation's output that is reinvested in R&D, as this ratio is an indicator of an economy's commitment to competing on the basis of new technology in the future. In this regard, the R&D intensity of the U.S. economy has remained essentially constant for 40 years, during which time the surge in foreign R&D investment has occurred.

The change in R&D funding patterns in technology has led to the broad dispersion of technology worldwide. The increase in foreign direct investment by many global firms has reinforced that

trend. Advanced, state-of-the-art manufacturing facilities capable of producing high-quality, low-cost goods are now available worldwide. American manufacturers face competition not only from manufacturers of low-cost commodity products, but also from manufacturers of sophisticated products and the tools to make them.

Thus, U.S. manufacturers will face constant pressure not only to lower prices, but also to increase the value that they add to their products. Competition from low-cost producers creates an incentive to move up the value chain in the direction of higher-margin goods, where the conditions of competition are not based on price alone. Increasingly, success in manufacturing will depend on the ability to integrate new technologies rapidly into both products and operations. That ability puts a premium on continuing R&D as the primary means of gaining a competitive edge.

Lowering Barriers to Trade

The second trend reshaping the environment in which U.S. manufacturers compete is the significant reduction in tariff and non-tariff barriers to trade in manufactured goods globally. Successive rounds of multilateral trade negotiations under the General Agreement on Tariffs and Trade and its successor, the World Trade Organization, for example, have cut the average tariff on manufactured goods worldwide by 30 percent. For industrialized countries the results are even more remarkable. According to a 1999 study published by the Organization for Economic Cooperation and Development, the average tariff rate for OECD countries, which was 40 percent at the end of World War II, is now 4 percent.[17] The more recent creation of free trade agreements, such as the North American Free Trade Agreement between the United States, Canada, and Mexico, has reinforced the trend. Over the past 10 years, NAFTA eliminated tariffs and many non-tariff barriers applicable to the largest three-way trade in the world.

The value of world trade has grown enormously as a result. Since the creation of the GATT system, world exports grew from $58 billion in 1948 to $5.98 trillion in 2001. According to data compiled by the WTO, the volume of world exports increased at a compound annual rate of 5.8 percent in the past 25 years alone, a pace that was more than twice as fast as growth in the world economy as a whole.[18]

U.S. manufacturers face considerably higher compliance costs than do many of America's trading partners

Most of the growth in world trade has been in manufactured goods. The sector now accounts for approximately three-fourths of all trade in goods and 60 percent of all trade, in goods and services combined.[19] One reason for the predominance of manufacuring trade is that the United States and its trading partners have reduced barriers to trade in manufactured goods further and faster than in other sectors. While trade in agricultural goods, for example, has grown at a relatively strong annual rate of 3 percent over the last 20 years, exports of manufactured goods advanced at nearly twice that rate, averaging 5.7 percent per year.

The growth in trade over the past 50 years, fueled by falling trade barriers, has contributed directly to the most rapid, sustained economic growth in U.S. history. Output in the United States increased fivefold and real GDP tripled. U.S. real GDP, expressed in 2000 dollars, grew from $11,672 in 1950 to $34,934 in 2002.

Trade continues to contribute significantly to U.S. economic growth. In the past decade alone—which included the creation of NAFTA, the conclusion of the Uruguay Round of GATT talks, and the creation of the WTO—world trade grew by 87 percent.[20] Between 1990 and 2000, U.S. exports were up 98 percent and the share of world trade represented by U.S.

exports actually grew from 11.4 to 12.2 percent.[21] In other words, rather than having a negative impact on the U.S. economy and manufacturing sector, the most recent round of trade agreements appears to have allowed U.S. exports to grow at a faster pace than world trade overall.

The U.S. economy grew rapidly over those same years, exceeding the pace of most other industrialized nations. From 1990 to 2002, the economy expanded at a 3-percent annual rate: the economy grew from $7 trillion in 1990 to $10 trillion in 2002.[22] During that time, the growth in U.S. exports accounted for one-sixth of all growth in the U.S. economy.[23] In sectors such as machinery, computers and electronics, and transportation equipment, exports now make up between 50 and 60 percent of all sales.[24] In one-third of U.S. manufacturing industries, exports account for one in every five manufacturing sales. According to the most recent figures available, exports now support more than 12 million jobs, and those jobs pay between 13 and 18 percent higher than the average U.S. wage.[25]

The benefits of trade, of course, flow from imports as well as exports. Reductions in tariffs on imports into the United States represent a cut in regressive taxes. This cut offers significantly higher benefits to low-income households than to those with higher incomes. By some estimates, NAFTA and the Uruguay Round agreements raised the average annual income of an American family of four by $1,300 to $2,000.[26] A further reduction in global barriers by just one-third would increase that family's annual average income by an additional $2,500 a year.[27]

The benefits from import competition are not limited to the final consumer. Access to the highest-quality, lowest-cost components is an essential element of the U.S. manufacturing sector's competitiveness. Imports stimulate competition and spur American manufacturing to increase its own quality and productivity. It is worth underscoring that during the past decade, while trade was expanding significantly, the U.S. manufacturing sector was growing faster and in more dynamic ways than it had in decades.

None of those results are surprising in economic terms. A more open economy has moved the United States toward the position of its greatest comparative advantage. This openness has brought about increasing returns and a more efficient use of resources. Both are consistent with stronger economic performance. Indeed, some of the latest research suggests that the broad engagement of the United States in the world economy—particularly the adjustment of the U.S. economy toward a more competitive state—has actually helped retain employment in the manufacturing sector that would have otherwise been lost.[28]

In fact, to the extent that other countries are currently examining the health of their own manufacturing sectors, they have identified the United States as the model. In its recent study of manufacturing in the United Kingdom, for example, the British government essentially benchmarked the U.S. manufacturing sector as the best measure of its own progress and policies.[29] Similarly, the European Union articulated a vision of aerospace manufacturing that expressly contrasted the development of their aerospace industry with that of the United States.[30] Many developing countries also use the United States as a model.

These developments point to the basic benefits to the U.S. economy, and to its manufacturing sector in particular, from participating in an increasingly open

trading system governed by a common set of rules. They also point to the benefits that can be derived, both for U.S. manufacturers and for the country, from the current effort to open markets through trade negotiations. Furthermore, vigorous enforcement of agreements is needed to ensure that U.S. manufacturers, together with the nation's farmers and service providers, receive the benefit of the bargains negotiated.

Given the concerns expressed throughout the U.S. manufacturing sector about the current trade rules, it is worth reiterating the extent to which the rules adopted in recent trade agreements have served, rather than undercut, U.S. economic interests, including those of U.S. manufacturers. Reducing tariff barriers, improving investment rules, and developing stronger intellectual property protections, for example, mainly benefit the small manufacturers that were previously locked out of foreign markets. While larger firms can afford to invest behind the "tariff wall" and have the resources, in many cases, to develop strategies for protecting their intellectual property, smaller manufacturers have generally had only two options: either export directly or sell to someone who exports.

In the aggregate, macroeconomic forces—rates of growth and relative prices—have the primary effect on our trade balance and help explain the trade deficit. These forces, combined with innovation and productivity, underpin our trade position over the long term.

On the other hand, from the perspective of individual firms, other factors can be seen as important in global markets and America's trade position. Continued trade deficits, combined with the very visible efforts by some countries to confer a competitive advantage on their firms, lead some U.S. manufacturers to question the fairness of our trade agreements and the basic tenets of U.S. trade policy.

The United States has led the way in reducing trade barriers worldwide and has, in past negotiations, proved willing to cut its tariffs and limit other forms of its own intervention in the market to a greater extent than a number of America's trading partners. While noting that there are significant exceptions, including in the manufacturing sector, the average U.S. tariffs on a trade-weighted basis are now less than 1.7 percent.[31] While many major industrial trading partners have also reduced their tariffs to comparable rates, in other parts of the world U.S. exporters still face heavy tariffs. In addition, the United States is far less likely to subsidize its manufacturers directly than is the case in many other countries.

the United States has led the way in reducing trade barriers worldwide

Wholly apart from the basic regulation of trade or the imposition of specific protective barriers lies the question of costs imposed by government. U.S. manufacturers face considerably higher compliance costs in labor, environmental, and other regulatory areas than do many of America's trading partners, particularly in the developing world.[32] But there is little doubt that the disparities in certain highly visible areas drive the perception of unfairness that permeates many of the concerns of U.S. manufacturers about the current trade rules.

In today's global economy, a policy of protection simply does not work. A good example is the tool and die industry. While the U.S. tool and die industry has sought protection from import competition, particularly from China, the industry was also among the most vociferous opponents of President Bush's imposition of tariffs on imports of steel into the United States in 2002. What the tool and die industry's position reflects is that protection invariably involves costs and can injure other U.S. industries, including many manufacturers. Instead, what U.S. manufacturers seek is simply to ensure

that the rules that apply to U.S. manufacturers apply to their competitors as well, especially in the case of competition with companies that benefit from heavy state intervention.

Overall, the U.S. economy has benefited from import competition, which has helped maintain the competitiveness of many manufacturing enterprises and has dampened inflation considerably. At the same time, however, stronger import competition has put extraordinary pressure on manufacturing industries, including steel, furniture, tool and die, foundry products, textiles and apparel, and automotive parts, while touching advanced technology sectors as well.

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Increasingly, competition in manufactured goods has been driven by the evolution of low-cost competitors in emerging Asian markets. In 1980, the United States, together with the European Community and Japan, dominated trade in manufactures, accounting for nearly 75 percent of the value of world manufactures exports according to WTO statistics. By 2001, however, that share had fallen by almost 15 percentage points, to 60 percent.

Emergence of New Competitors

The third powerful trend affecting the manufacturing sector globally is both political and economic. It involves the increasing reliance of other countries, notably China and the nations of the former Soviet Union, on market mechanisms, rather than government planning, as the principal means of structuring their economies.

Though not often thought of in trade terms, the economic consequences of the end of the Cold War may have had the most profound effect of all. The end of the Cold War marked the end of political and economic divisions that had split the world in one way or another since the onset of World War I. Even with the rapid changes in technology and the reduction of tariff and non-tariff barriers to trade, the global economy would not be possible if those divisions still existed.

The numbers bear this theme out. While the so-called Asian tigers' share of world trade grew rapidly over the past 20 years, the biggest gains in share of world trade in manufactures were captured by China. China's manufactured exports increased from only 0.8 percent of world shipments in 1980 to 5.3 percent in 2001. With the onset of economic reforms in 1979 and a heavier reliance on market forces, China has rapidly expanded its trade in manufactured goods. China now ranks fourth among exporters of manufactures worldwide.

It is worth underscoring that virtually all of the market share gains of China and other Asian nations have come at the expense of Japan and Europe, while the U.S. share of world exports of manufactured goods actually increased marginally between 1980 and 2001, from 13 percent to 13.5 percent.[33] That increase, in turn, is due to the ability of U.S. manufacturers to raise their productivity significantly over the same period. At the same time, however, U.S. manufacturers in a variety of sectors were seeing their share of the U.S. market eroded.

There is another side to the political and economic revolution that has taken place over the past two decades; any form of economic restraint has the effect of creating imbalances between demand and supply. Consequently, when those restraints are removed, capacity often exceeds demand, and the markets must adjust to bring supply and demand back into equilibrium.

The end of the Cold War and China's reentry into the world economy had a similar effect. A recent study of trends in manufacturing employment illustrates this. The study showed that manufactur-

ing employment has fallen not only in the United States, but also around the world.[34] In fact, China's manufacturing employment has actually fallen faster than that of the United States in percentage terms in recent years.[35]

This decline in employment largely reflects the gradual privatization of China's many state-owned enterprises and the subsequent reduction in employment as they adjust to competing in world markets. However, it also underscores the effect of rising global productivity and the extent of the excess capacity in manufacturing that continues to put downward pressure on the price of manufactured goods worldwide.

Shift toward Global Outsourcing

The practical effect on U.S. manufacturers of the three trends described above has been to increase the availability of new sources of low-cost labor and manufacturing capacity. Indeed, the trends have not only made it available, they have also made it an important competitive issue. In a global economy in which both goods and capital are mobile, but labor is not, manufacturers' tapping of lower-cost labor by importing it in the form of lower-cost parts, components, and—increasingly—finished goods is simply a function of trying to stay competitive in a global economy.

Hence, the trend toward sourcing parts and components globally is driven by powerful competitive forces and is here to stay. Manufacturers now have the ability to manage global supply chains effectively, which allows them to source from the lowest cost supplier globally and, as a competitive matter, forces them to do so in order to remain competitive themselves.

In an increasingly global market for manufactured goods, competition will largely take place among supply chains, rather than between individual manufacturers. That implies an entirely different concept of manufacturing. Rather than focusing on what traditionally defined manufacturing—that is, the process of turning raw materials into components or finished products—manufacturers today think of manufacturing as a system designed to perform the activities required to deliver the end-product to the customer and meet the customer's needs, from design to finance to production to sales and marketing to after-sales service.

Thought of in that way, the structure of manufacturing no longer implies that all of those processes need take place in a single enterprise. Manufacturers increasingly see themselves as system integrators, managing a supply chain or "virtual network" that may consist of any combination of the activities mentioned above, whether or not provided by the "manufacturer" itself.

Adapting to this changing competitive environment has forced U.S. manufacturers to adopt new production, marketing, and management methods, from "lean manufacturing" techniques, to quality assurance programs that guarantee zero defects, to international product standards so their goods can be incorporated in other firms' global supply chains. It also means an increasing demand to reach out to customers worldwide in order to show how a manufacturer can add value to the customer's product and its supply chain.

competing in a global marketplace puts a premium on government getting the economic fundamentals right to create an environment in which U.S. manufacturing can flourish

The automotive sector provides a case in point. Whereas U.S. automobile manufacturers once provided a ready market for many domestic suppliers of parts and components, the manufacturers now operate on a global basis. Thus, automotive parts suppliers must now find niches in the global supply chains of U.S. auto companies or their foreign competitors to succeed in today's market. That brings

U.S. auto parts suppliers into head-to-head competition with parts suppliers worldwide. The possibility of relying on increased auto sales in the United States that automatically translate into increased orders for parts and components for U.S. suppliers simply no longer exists. Competition now takes place on a global basis, and that fact will continue to shape the prospects for the manufacturing sector in the future.

The Government's Role: Getting the Fundamentals Right

The changing nature of competition requires, correspondingly, a different way of looking at government policy. This means fostering an economic environment, both domestically and internationally, that encourages growth, rewards sound investment, controls costs, and fosters innovation and rising productivity. It also means an aggressive international economic policy that ensures a level playing field by reducing barriers to trade and investment and vigorously enforcing the trade rules when violated.

Competing in a global marketplace puts a premium on government getting the economic fundamentals right to create an environment in which U.S. manufacturing can flourish. It means examining whether the U.S. government's actions and the structure of the U.S. market improve or hinder the ability of American firms, in manufacturing and throughout the economy, to compete in an increasingly global marketplace.

Notes:

[1] Bureau of Economic Analysis, U.S. Department of Commerce (2002). Calculations based on total requirements matrix from the BEA Web site, *www.bea.doc.gov*. Considered on an aggregate basis, total manufacturing shipments in the most recent 12-month period were $4 trillion, but only roughly 40 percent of this was value added in the manufacturing sector. The rest was either duplicate shipments as goods were shipped from one manufacturing processor to another, or inputs from other sectors-agricultural products into food manufacturing, crude petroleum into petroleum refining, and iron ore into steel manufacturing, as well as contributions from the transportation, financial, and business services sectors.

[2] Productivity is defined as the amount of goods and services produced, adjusted for inflation, per hour of work.

[3] See, for example,William J. Baumol, *The Free-Market Innovation Machine—Analyzing the Growth Miracle of Capitalism* (Princeton, N.J.: Princeton University Press, 2002); see also Michael E. Porter, "Building the Microeconomic Foundations of Prosperity: Findings from the Microeconomic Competitiveness Index" in *The Global Competitiveness Report* (Geneva: World Economic Forum, 2003).

[4] Michael E. Porter, *The Competitive Advantage of Nations*, 1st ed. (New York: The Free Press, 1990).

[5] Gregory C. Tassey, *R&D and Long-Term Competitiveness: Manufacturing's Central Role in a Knowledge-Based Economy*, Planning Report 02-2 (Gaithersburg, Md.: National Institute of Standards and Technology, February 2002).

[6] R. McGuckin and B. van Ark, *Productivity, Employment, and Income in the World's Economies* (New York: The Conference Board, 2002).

[7] Thomas J. Duesterberg and Ernest H. Preeg, eds., *U.S. Manufacturing: The Engine for Growth in a Global Economy* (Westport, Conn.: Praeger, 2003).

[8] Baumol, *Free-Market Innovation Machine.* Baumol makes that point a central theme in his recent work on the determinants of economic growth. He finds that "the social benefits contributed by the initial innovations are typically smaller than those provided by the accumulation of subsequent incremental improvements." Baumol points to the rapid improvement in performance and reduction in the cost of computers, which is largely attributable to the incremental improvements in production technology, rather than a quantum leap in the form of an entirely new way of computing.

[9] U.S. Department of Labor, Bureau of Labor Statistics, "Employment Cost for Employee Compensation" (Nov. 25, 2003).

[10] Robert Solow, review of Stephen Cohen and John Zysman, *Manufacturing Matters: The Myth of the Post-industrial Economy* in *The New York Times Book Review* (July 12, 1987).

[11] Roger E. Alcaly, *The New Economy* (New York: Farrar, Straus, and Giroux, 2003).

[12] Ibid.

[13] Diane Coyle, *The Weightless World* (Cambridge, Mass.: MIT Press, 1998).

[14] Robert Gordon, "Technology and Economic Performance in the American Economy," National Bureau of Economic Research Working Paper, no. 8771 (February 2002).

[15] *Economic Report of the President* (January 2001).

[16] Ibid.

[17] Organization for Economic Cooperation and Development, *Post-Uruguay Round Tariff Regimes: Achievements and Outlook* (Paris: OECD, 1999).

[18] World Trade Organization, *International Trade Statistics* (Geneva: World Trade Organization, various editions).

[19] World Trade Organization, *International Trade Statistics 2002* (Geneva: World Trade Organization, 2002).

[20] International Monetary Fund, *Direction of Trade Statistics* (Washington, D.C.: International Monetary Fund, 1981–2002), data from various editions.

[21] Ibid.

[22] U.S. Department of Commerce, Bureau of Economic Analysis.

[23] Ibid.

[24] Bureau of the Census, Annual Survey of Manufactures and foreign trade data in the FT 900 releases for 2001and 2002.

[25] U.S. Department of Commerce, Economics and Statistics Administration, "U.S. Jobs Supported by Goods and Services Exports, 1983–94," staff research report, November 1996.

[26] Drusilla K. Brown, Alan V. Deardorff, and Robert M. Stern, "Computational Analysis of Multilateral Trade Liberalization in the Uruguay Round and Doha Development Round," Discussion Paper no. 489 (Ann Arbor, Mich.: Research Seminar in International Economics, 2002).

[27] Idem, "Multilateral, Regional, and Bilateral Trade-Policy Options for the United States and Japan," Discussion Paper no. 490 (Ann Arbor, Mich.: Research in International Economics, 2002).

[28] Lori G. Kletzer, "Imports, Exports, and Jobs: What Does Trade Mean for Employment and Job Loss?" unpublished paper for the W.E. Upjohn Institute for Employment Research, December 2002.

[29] United Kingdom, Department of Trade and Industry, *Manufacturing—a Sector Study; the Performance of Manufacturing Companies within Benchmark Index* (Staffordshire, England: Benchmark Index, 2002).

[30] European Commission, *Star21: Strategic Aerospace Review for the 21st Century* (Brussels: European Commission Enterprise Publications, 2002).

[31] U.S. International Trade Commission calculations for all goods in 2002, including preferences. Examples of exceptions in the manufacturing sector include tariffs over 50 percent for certain footwear and over 30 percent for certain apparel.

[32] Jeremy A. Leonard, "How Structural Costs Imposed on U.S. Manufacturers Harm Workers and Threaten Competitiveness," NAM/MAPI study, December 2003.

[33] World Trade Organization, *International Trade Statistics, 2002*.

[34] Joseph G. Carson in Alliance Capital's *U.S. Weekly Economic Update* (October 2003).

[35] Ibid. China's manufacturing employment declined by 15 percent from 1995 to 2002, while U.S. manufacturing employment declined 11 percent over the same period.