Securing America's Future:

The Case for a Strong Manufacturing Base

A Study by Joel Popkin and Company, Washington, D.C.
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EXECUTIVE SUMMARY

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U.S. manufacturing is the heart of a significant process that generates economic growth and has produced the highest living standards in history. But today this complex process faces serious domestic and international challenges which, if not overcome, will lead to reduced economic growth and ultimately a decline in living standards for future generations of Americans.

Manufacturing's innovation process is the key to past, present and future prosperity and higher living standards. The intricate process starts with an idea for a new product or process, prompting investments in research and development. R&D successes lead to investments in capital equipment and workers, and to "spillovers" that benefit manufacturing and other economic sectors. This process not only generates new products and processes, but also leads to well-paying jobs, increased productivity, and competitive pricing. Yet while this process produces wealth and higher living standards, most of it is hidden from view and poorly understood.

Manufacturing's innovation process provides enormous benefits for the entire U.S. economy:

- **Grows the Economy** - Manufacturing growth spawns more additional economic activity and jobs than any other economic sector. Every $1 of final demand for manufactured goods generates an additional $0.67 in other manufactured products and $0.76 in products and services from nonmanufacturing sectors.

- **Invents the Future** - Manufacturers are responsible for almost two-thirds of all private sector R&D – $127 billion in 2002. Spillovers from this R&D benefit other manufacturing and nonmanufacturing firms. R&D spillovers are enhanced by geographic proximity.

- **Generates Productivity Increases** - Manufacturing productivity gains are historically higher than those of any other economic sector – over the past two decades, manufacturing averaged twice the annual productivity gains of the rest of the private sector. These gains enable Americans to do more with less, increase our ability to compete, and facilitate higher wages for all employees.

- **Provides More Rewarding Employment** - Manufacturing salaries and benefits average $54,000, higher than the average for the total private sector. Two factors in particular attract workers to manufacturing: higher pay and benefits, and opportunities for advanced education and training.

- **Pays the Taxes** - Manufacturing has been an important contributor to regional economic growth and tax receipts at all levels of government. During the 1990s, manufacturing corporations paid 30-34 percent of all corporate taxes collected by

state and local governments, Social Security and payroll taxes, excise taxes, import and tariff duties, environmental taxes and license taxes.

Meanwhile, other nations, recognizing that a strong manufacturing base is the proven path to a world-class economy, have been learning from the American example and are forging their own innovation processes to compete with ours.

America's manufacturing innovation process requires a critical mass to generate wealth and higher standards of living. If the U.S. manufacturing base continues to diminish at its present rate that process may deteriorate beyond repair and with it the seedbed of our industrial strength and competitive edge.

The most serious challenges to the long-term viability of the U.S. manufacturing base and the innovation process that underlie it are:

- **Loss of Jobs** - U.S. manufacturers historically lead the way in an economic expansion, but are still struggling to recover from the recent recession. Since July 2000, manufacturing has lost 2.3 million jobs, many of which have been outsourced or relocated overseas. Manufacturing output has shown virtually no growth since December 2001 – the official end of the recession – in the weakest manufacturing recovery since 1919.

- **Loss of Export Potential** - Manufacturing exports as a share of GDP have contracted since 1997, reflecting the strong dollar overseas, the impact of the recession on our trading partners, the terrorist attacks in the United States in September 2001, and increased global competition. The U.S. trade deficit has ballooned to historic highs – reflecting an increase in purchases of foreign-made goods, especially from countries which do not freely float their currencies.

- **Investments are Going Elsewhere** - U.S. manufacturing's share of capital investment and R&D expenditures, once a dominant feature of our nation's commitment to progress, is diminishing. While U.S. manufacturers conduct two-thirds of private R&D, their R&D spending between 2000 and 2002 grew at only half the pace of the previous decade.

- **Needs More Skilled Workers** - Despite the loss of 2.3 million jobs, manufacturing is facing a potential shortfall of highly qualified employees with specific educational backgrounds and skills, especially those specific skills needed to produce manufactured goods. If the skills and knowledge of the American workforce do not improve it will be detrimental to manufacturing's competitive edge and to the prospect for economic growth.

- **Faces Dramatically Rising Costs** - The cost of doing business in the United States is rising dramatically, in large measure because of significant costs related to healthcare, litigation, and regulation. As a result, many U.S. manufacturers shut down or move production overseas to countries where they do not face, to the same extent, those kinds of impediments to reducing productions.

U.S. manufacturing's innovation process leads to investments in equipment and people, to productivity gains, to beneficial spillovers, and to new and improved products and processes. This intricate process generates economic growth and higher living standards superior to any other economic sector. But serious challenges threaten to undermine the critical mass of manufacturing necessary to maintain a dynamic innovation process**. If the U.S. manufacturing base continues to shrink at its present rate and the critical mass is lost, the manufacturing innovation process will shift to other global centers. Once that happens, a decline in U.S. living standards in the future is virtually assured.**

I. Introduction

Manufacturing has long been recognized as the engine of our economic growth. Over half of the acceleration in labor productivity over the past 10 years can be attributed to strong gains in total factor productivity in the manufacturing sector. Productivity growth is the major contributor to our prosperity: our tangible wealth and standard of living. Manufacturing's contribution to U.S. prosperity may be most visible in the enviable position of the United States in Gross Domestic Product (GDP) per capita: In 2002, the United States ranked 40 percent above the average for the 15 countries in the European Community, 35 percent above Japan and 20 percent above Canada on a GDP per capita basis.[1]

But there has been concerned discussion, if not alarm, voiced recently that the growth engine is losing steam. U.S. Representative Vernon Ehlers of Michigan recently stated: "Manufacturing in the United States is in trouble [and] the public doesn't even understand what manufacturing is. We have to revitalize the public perception." [2] This paper is a first step toward accomplishing that.

Manufacturing can be described as the set of activities that transform agricultural and mineral resources into finished goods. This process usually involves several steps within manufacturing, as the sector encompasses all activities from the first transformation of raw materials to the final assembly of finished goods.

The U.S. manufacturing sector should not be taken for granted. It is at the heart of a process that is critical to the health of the U.S. economy — the process of generating prosperity, *i.e.*, wealth and real income gains. Because this process — basically an innovation process — is intensely interactive, its maintenance requires a

[1] GDP per capita in Purchasing Power Standards, Eurostat, April 15, 2003. This is based on per capita GDP measured using purchasing power parities (PPPs). PPPs are country price relatives and are considered a more accurate way of producing comparable GDP numbers than using market exchange rates. The Organization for Economic Co-operation and Development (OECD) and Eurostat (the European statistical agency) produce the PPP measures. Luxembourg has a per capita GDP measure that is higher than all of the other countries including the U.S. However, it is in a unique situation in that almost a quarter of all its workers are frontier workers; they produce goods and services that appear in Luxembourg's GDP but are not residents of the country and therefore are not included in the population count that is used to produce the per capita number.

[2] *Manufacturing and Technology News,* Annandale, Va.: Publishers and Producers, April 1, 2003, p. 3.

strong, growing manufacturing sector. It is perhaps easiest to understand this innovation process by tracing the interactions beginning with an initial component: research and development. R&D is diffused through the economy in numerous ways. The most obvious direct linkage is through the production of new goods, and of improved quality in existing goods. Successful R&D not only affects the kinds of goods that flow to consumers but also enhances the labor and capital inputs used to produce them. As capital goods are improved in speed, accuracy, and quality they rely on new processes to make their utilization most efficient. Reaping the benefits of such improvements in manufacturing processes requires that human capital (skills) keep pace, largely through education and training. But this R&D-driven process does not stop there. It is magnified by "spillovers," channels by which an innovation in one area freely stimulates those in other areas.

Large and frequent innovations, the hallmark of U.S. manufacturing, require a certain mass of interconnected activities which, like a snowball rolling downhill, grows in size as it proceeds toward final consumers. The snowball effect requires substantial R&D, enough to be sure of significant successes after writing off failures. The successes must be frequent enough to keep the ball rolling through interactions among the different parties to the process. As size and frequency of innovations rise, spillovers are magnified. Their impact is significantly enhanced by proximity — most importantly geographical closeness — enabling the transmission of products and ideas upstream and downstream among suppliers and customers. The vehicles for those transmissions are sales transactions, face-to-face discussions of ideas and needs, professional meetings of scientific professionals and scientific literature written in a common tongue, etc. To establish this process of wealth generation throughout the economy and maintain its momentum requires a certain immeasurable mass of all these activities.

The plethora of economy-wide benefits manufacturing produces can be classified into five broad categories, presented in Section II of this paper. However, the continuation of those benefits lies in doubt if manufacturing shrinks to a point where the process that generates jobs and wealth breaks down. Section III identifies some

troublesome signs of potential breakdown. The final section summarizes the current state of manufacturing and the danger posed to future American prosperity.

II. U.S. Manufacturing's Significance to Economic Prosperity

Manufacturing transforms raw materials into finished goods. The importance of these activities is obvious in a broad array of statistics and analyses that show the essential role the domestic manufacturing base plays in U.S. economic growth. Manufacturing's benefits to the economy can be summarized into five broad categories discussed below. The first is the most obvious, the direct links between manufacturing growth and growth in the rest of the economy. Those links can be seen in the growth generated in other sectors of the economy when there is an increase in the demand for manufactured goods; in the role manufacturing plays to generate growth in the basic infrastructure of the economy; and in the importance of the manufacturing base in generating exports. The second broad category of benefits flows from productivity-enhancing investments made by manufacturers in capital equipment and, even more importantly, in R&D. The third category of benefits flows from the productivity gains that make possible increases in the standard of living. The fourth consists of benefits to the U.S. labor force (1) accruing directly from the wages and benefits good manufacturing jobs provide, and (2) from the education and training investment in human capital that is needed to maintain the process. Finally, a strong manufacturing sector results in substantial consumer benefits. Chief among those are more and better products available at prices that are little changed over the past decade. Each of these five categories of benefits is discussed below, followed by a short section on how these benefits manifest themselves in the economies of individual states.

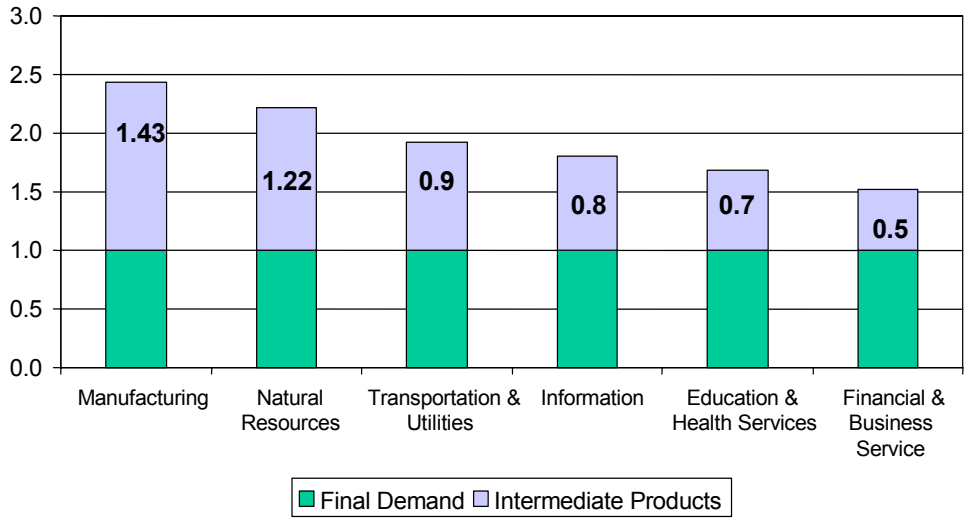
A. Manufacturing's Direct Links to Economic Growth

The manufacturing sector is the heart of the innovation process not only because of its direct role in producing and commercializing innovations but also because its direct and substantial links to other sectors spread those impacts throughout the economy. These links work both backward to mining and other raw material producing sectors, and forward into the transportation and trade sectors that are delivering the goods to final consumers. Thus, as manufacturing output grows it requires more inputs, and in turn spurs the creation of jobs, investments, and innovations in other sectors of the economy. This effect can be quantified in a number, referred to as a "multiplier,"

that shows how much intermediate and final output is generated by a dollar's worth of final demand for manufactured products.

The Commerce Department's Bureau of Economic Analysis (BEA) calculates multipliers for each major sector of the economy. The most recent set of data, released at the end of 2002, show the manufacturing multiplier is 2.43: $1 in final demand manufactured products and $1.43 for intermediate products and services. [3] The natural resource producing sector has a multiplier of 2.22, almost as large as manufacturing. However, the multipliers for the major service-producing sectors are much smaller (1.8 for information services, 1.7 for education and health services, and 1.5 for financial and business services.) [4] This multiplier effect also means that an increase in the demand

Chart 1: Multipliers for Selected Sectors of the Economy



Source: Bureau of Economic Analysis

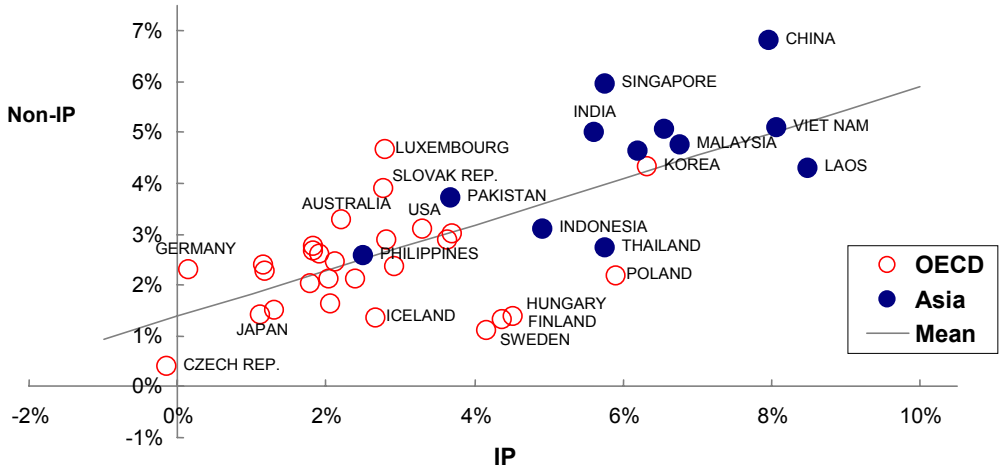
[3] An alternative way to describe this relationship: To satisfy a dollar's worth of final demand for manufactured products generates demand of $1.67 from manufacturing (some of it for final products and some from intermediate parts and components) and $0.76 from other sectors of the economy.
[4] These multipliers are calculated from the latest benchmark I-O matrix, the first incorporating the North American Industrial Classification System (NAICS). The change to the new classification system provides a more detailed look at the multipliers for the service-producing sectors.

for manufactured products increases the demand for both manufacturing and non-manufacturing jobs.

The importance of the larger multipliers associated with manufacturing and mineral processing can be seen by looking at the relationship between real growth in manufacturing, mining and utility output (IP) and the real growth in the other sectors of the economy (non-IP). That relationship is shown in Chart 2 for 40 economies within the Organization for Economic Co-operation and Development (OECD) and Asia. The positive relationship is significant by statistical tests. For every 1.0 percentage point rise in manufacturing output, non-industrial production rises by almost a half percentage point. The result suggests that economies with no growth in manufacturing would experience economic growth of less than 1.5 percent per year, reflecting the lower growth-generating power of the non-industrial sectors. During the 1990s the U.S. economy grew at an enviable rate of 3.2 percent per year, on average, very similar to its average rate of growth over the past 50 years. A drop to a 1.5 percent GDP growth rate, less than half of what the United States has recently experienced, would have many adverse consequences on America's prosperity.

Chart 2: OECD and Asian Countries

10-Year Average Growth of Industrial Output (IP) and Non-Industrial Output (Non-IP)



Source: OECD and Asian Development Bank

The size of the multiplier does not capture all of manufacturing's impact, only those that can be quantified by measuring inter-industry transactions. The multiplier does not capture the externalities produced by the right kind of linkages, spillovers being one of the more important examples. These links are much more difficult to quantify, but a conceptual framework provides a better understanding of how the parts, together, may be stronger than each individual part alone. Cohen and Zysman, in their book *Manufacturing Matters: The Myth of the Post-Industrial Economy,* state it this way:

> What matters to us most are the links that promote ongoing market adaptation and technological innovation. Advanced computers and telecommunications equipment depend on innovation in electronic devices. An expanding telecom industry provides a market for computers and microelectronics components. Japan's early advantage in certain advanced semiconductor products — for example, CMOS (complementary metal on silicon) memory chips [footnote omitted] — was built on its market position in consumer electronics. This instance suggests a broader conclusion: advantage in a national economy is embodied not simply in the capacities of specific firms but in the web of interconnections that establishes possibilities for all firms.
>
> Technological innovation depends on a series of subtle and complex interconnections. Knowledge of auto manufacturing or airplane manufacturing promotes innovation in machine tools, and advances in machine tools permit production innovation in many other industries. The wide-spread technological interplay involving small improvements may be even more important than the dazzling breakthroughs.[5]

In his book *The Free-Market Innovation Machine*, William Baumol refers to this process as the cumulative nature of innovation or as "innovation breeding." [6] The importance of this process in generating investment and R&D will be discussed later in this paper.

One particularly important link is between manufacturing and the distribution networks: communications, transportation, utilities and trade. Those infrastructure networks are the vital link between the production of goods and services and their delivery to buyers. Such networks are much more capital-intensive than other service-

[5] *Manufacturing Matters: The Myth of the Post-Industrial Economy*, Stephen Cohen and John Zysman, Basic Books, Inc. Publishers, New York, 1987, p. 102.
[6] *The Free-Market Innovation Machine*, William J. Baumol, Princeton University Press, 2002.

producing industries, requiring capital and other manufactured goods to construct and maintain them. Thus, the production of goods drives the demand for infrastructure and the growth of infrastructure fuels the demand for manufacturers, creating synergies for investments in both sectors.

Most products hauled by the major modes of transportation in the country are tied to manufacturing. About 70 percent of all ton-miles of products carried by trucks are manufactured products, and they account for 87 percent of the value of goods hauled by trucks. For rail transport, about 80 percent of the value of products transported are manufactured goods.[7] If the raw materials being transported for input into the manufacturing process are also considered, these percentages are higher still. Manufactured goods require a good transportation system which, in turn, promotes improvements in the transportation networks.

Transportation networks are not the only infrastructure impacted by the manufacturing industry. Modern communications networks are also an increasingly important tool in improving efficiency. Basic mail and telephone networks have always been, and continue to be, important in connecting manufacturers to their suppliers and customers. However, manufacturing is making more intensive use of communications networks to increase its efficiency. In 2000, 38 percent of manufacturing plants used electronic networks to place online orders for materials and supplies. Of those plants, 83 percent used either the Internet or Electronic Data Interchange to process their transactions.[8] In 2001, 18 percent of manufacturing shipments, worth $725 billion, were sold online through electronic networks.[9]

The manufacturing sector's recognized need for, and innovative use of, infrastructure makes it profitable for infrastructure producers to make investments. However, improvements in infrastructure are not limited to just the users in manufacturing — those improvements provide benefits to everyone. Infrastructure

[7] *1997 Commodity Flow Survey*, Census Bureau, U.S. Department of Commerce, Table 7.
[8] *E-Stats*, "Detailed Tabulations of Manufacturing E-business Process Use in 2000", Census Bureau, March 2002.
[9] *E-Stats,* "E-Commerce 2001 Highlights," Census Bureau, March 2003.

networks are strategic assets for an economy. They must link major producer and consumer markets, be operated at high-utilization rates and have access to state-of-the-art technological innovations. Consequently, innovations in one sector are likely to fuel innovations in the other sector, and both sectors will develop better methods of using those innovations most effectively.

Manufacturing also directly links the U.S. economy to other economies around the world. The United States is the world's largest exporter of manufactured goods. In 2001, it exported almost $600 billion worth of goods. U.S. manufactured exports have more than doubled since 1990, and manufactured goods account for 82 percent of the United States' total merchandise exports and three-quarters of all its exports. While U.S. manufactured exports as a share of world trade have remained relatively constant through most of the past two decades — 13 percent in 1980, 12.1 percent in 1990 and 13.5 percent in 2001 — trade has become an increasingly important part of the economy of the United States and that of other countries around the world.[10]

America's success as an exporter has prompted other countries to build their own base for manufacturing exports. As world trade burgeoned in the 1990s, increasing from $4.2 trillion to $7.9 trillion, manufactured goods as a share of total world exports also increased from about 70 percent of the world's merchandise trade to about 75 percent. U.S. businesses and consumers have become the buyers for many foreign-manufactured products; thus, traded goods have become an increasingly large share of the American market. The sum of U.S. exports and the imports of manufactured goods is now equal to 40 percent of U.S. domestic production of manufactured goods. In 1987 that share was 20 percent.[11]

Continued growth in U.S. exports is vital to enabling the United States to trade with the rest of the world. Exports earn foreign currency, and foreign-currency earnings

[10] The U.S.'s manufactured imports share of world trade has grown tremendously during this time period increasing from 11.2 percent in 1980 to 15.4 percent in 1990 and was 19.4 percent in 2001. This reflects the strong import competition that U.S. manufacturing companies have faced over the past 20 years. *International Trade Statistics, 2002*, World Trade Organization.

[11] Based on U.S. Department of Commerce data on manufactured exports and imports and manufacturers' shipments.

support jobs and allow the United States to purchase foreign-made imports. The International Trade Administration estimates that one in five manufacturing jobs is tied to exports of manufactured products, and for each of those manufacturing jobs there are 1.3 non-manufacturing jobs tied to manufactured exports.[12]

Manufacturing R&D is an important driver in spurring growth in U.S. exports. Exports of R&D-intensive goods are a growing share of overall goods exports by the United States. In 1980 exports of such goods accounted for about 19 percent of all manufactured exports in the United States; by the late 1990s that share had grown to about 27 percent.[13] However, by definition goods high in R&D content are those embedding new and better ideas. The world buys U.S. exports because they are "the better mousetrap." Maintaining the growth in such goods requires a sizable continuous stream of investment in R&D, and a vibrant manufacturing sector to innovate, produce and sell those goods abroad.

B. Manufacturers' Capital Investments and R&D are Key To Growth

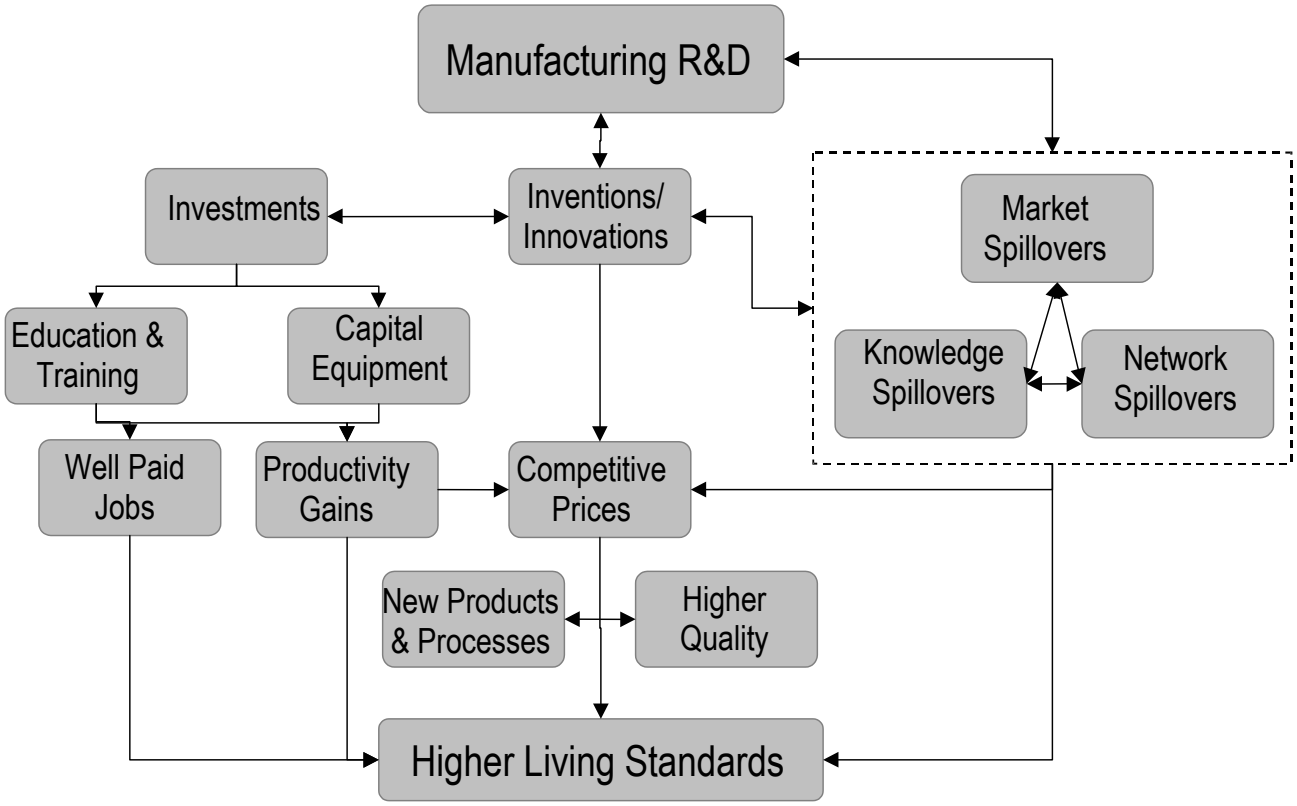
Manufacturers' investment in physical and human capital, R&D, and productivity are intertwined and together provide substantial economic benefits. This is the method by which innovations become an integral part of the economic process and lead to widespread improvements in productivity. A simplified schematic of the innovation process is shown in Figure 1.

Investment in new equipment provides each worker with more and better capital with which to work. This is often called “capital deepening” or an increase in the ratio of

[12] "U.S. Jobs from Exports," International Trade Association, U.S. Department of Commerce, 2001.
[13] R&D intensive goods as defined in this case are biotechnology, life science technologies, opto-electronics, information and communications, electronics, flexible manufacturing, advanced materials, aerospace, weapons, and nuclear technology.

Figure 1: Manufacturing Matters

Its Innovation Process Generates Wealth



A thorough quantitative investigation of the relationship between manufacturing and economic growth was conducted in the early 1990s for the World Bank by J. Bradford De Long and Lawrence H. Summers.[16] The study covered the period from 1960 to 1985, and looked at the behavior of a cross section of 61 nations at various

[14] A recent study published by the Federal Reserve finds that perhaps as much as two-thirds of recent gains in plant level multi-factor productivity in manufacturing between 1972 and 1996 can be attributed to technological advances embodied in capital equipment. "The Production-Side Approach to Estimating Embodied Technological Change," by P. Sakellaris and D. Wilson, March 2001.

[15] "Information Technology and Productivity: Where are We Now and Where are We Going?" Stephen Oliner and Daniel Sichel, Federal Reserve Board Working Paper, May 2002.

[16] "Equipment Investment and Economic Growth: How Strong is the Nexus?", by J. Bradford De Long and Lawrence H. Summers, October 1992.

stages of development. It confirmed the relationship and identified capital investment in equipment as a key contributor to manufacturing's importance as a growth generator.

In addition to producing a steady stream of improved capital equipment for other industries to use, manufacturing firms themselves have been significant investors in capital equipment. Over the past 20 years, manufacturing industries have accounted for 20–30 percent of new investment in equipment and 8–12 percent of new nonresidential structures.[17]

Even more important, manufacturers are the major dynamo of R&D. Over the past 20 years, manufacturing has performed almost 60 percent of all R&D in the United States. The National Science Foundation estimates total U.S. R&D spending in 2002 at $291 billion.[18] Of that amount, R&D performed by private industry is estimated at $213 billion. Detailed 2002 R&D totals by industry have not yet been published, but R&D performed by manufacturing industries is estimated at $127 billion, or 67 percent of the total private R&D, and about 45 percent of all R&D performed in the United States.[19] In 2000, manufacturing industries financed (as well as performed) about 55 percent of all private R&D. The remainder of the funding came primarily from the federal government; however, the federal government's financing of R&D performed by industry has been virtually unchanged in recent years.

Manufacturing R&D is conducted in a wide array of industries and businesses of all sizes. The heaviest R&D expenditures take place in computers and electronics, transportation equipment, and chemicals (primarily pharmaceuticals). Those three sectors together accounted for 75 percent of all manufacturing R&D in 2000. The remaining 25 percent is distributed among virtually every other manufacturing sector, with machinery and medical equipment being the next largest investors. [20]

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[17] Bureau of Economic Analysis, U.S. Department of Commerce, Investment in Private Equipment and Software by Industry.
[18] "Slowing R&D Growth Expected in 2002," National Science Foundation *InfoBrief* (NSF 03-307), December 2002.
[19] Estimates of manufacturing sector R&D are based on detailed 2000 distributions applied to 2002 industry totals.
[20] Preliminary tables for industrial R&D, National Science Foundation, December 2002.

R&D is also spread across firms of different sizes. Large firms dominate R&D, but firms with fewer than 500 employees conducted about 18 percent of total industrial R&D in 2000. Within manufacturing, firms with fewer than 15 employees conducted about 2 percent of industrial manufacturing R&D. A recent Small Business Administration (SBA) study found that small business, whose share of manufacturing output has been growing, has produced more than its share of technically important patents.[21]

The process through which R&D promotes economic prosperity is multi-faceted and complex. The first avenue is through direct benefits to firms from their R&D investments. Those direct benefits, or the potential benefits a rival might gain from R&D, are the primary driver of firm-financed R&D. The second is through "spillovers" whereby R&D performed by one firm benefits other firms without direct compensation for the innovation. The third is the feedback from R&D and its spillovers to improve manufacturing products, processes and distribution networks. The fourth is through the widely discussed multiplier — the effect of one industry's investment on others and the U.S. economy as a whole.

R&D spillovers are an important factor in this process. Spillovers come about when parties derive benefits from the R&D without having to fully compensate the company conducting the research. Spillovers are often characterized in one of three ways, but these pathways often interact and increase their combined effect.[22] One way is through "market spillovers," in which the marketing of a new product creates benefits to market participants other than the innovating firm. Often this is through a new technology that is embodied in products newly developed or improved by R&D. However, because producers fail to capture all of the improvements in the prices they charge for those new goods, cost-free benefits accrue to competitors and customers, or

[21] "Small Serial Innovators: The Small Firm Contribution to Technical Change," CHI Research, Inc. Produced under contract to the Office of Advocacy, 2003.
[22] "The Importance of 'Spillovers' in the Policy Mission of the Advanced Technology Program," by Adam B. Jaffe, *Journal of Technology Transfer*, Vol. 23 (2), pp. 11-19.

are handed back to suppliers.[23] A second kind is termed a “knowledge spillover.” This is the transmission of knowledge from an R&D activity that can be used by other economic agents in a virtually cost-free manner. A third kind is a “network spillover.” It occurs when R&D benefits are enhanced in value by the development of a related set of technologies. Thus, extra benefits may accrue to an innovation if related technological innovations also take place. For example, the existence of a modem allows greater benefits to be derived from computers, and the more people one can communicate with in that network the greater those benefits.

It is widely recognized that spillover effects are magnified — through sales transactions and knowledge transfers — the more interdependent the parties are and the closer their geographic proximity. A recent paper by Michael Orlando discusses the importance of proximity, both technological and geographical, to the spillover process. According to Orlando, his results are "consistent with intuition and existing empirical evidence which suggests that both geographic and technological distance attenuate knowledge spillovers." He finds that spillovers within a manufacturer's own very narrow sector tend to be much less sensitive to distance than are those from outside that narrow sector, however, a combination of geographic and technological nearness seems to be advantageous. Nevertheless, the impact from spillovers originating outside the manufacturers' narrow sector tends to decrease rapidly with distance.[24] Therefore, firms are more likely to benefit from spillovers when R&D takes place geographically near to them than they are if it occurs on the other side of the world, especially with regard to the benefits from more generalized R&D.

National Institute of Standards and Technology economist Gregory Tassey puts the importance of domestic R&D into a broader perspective:

> Changes in competitive dynamics are altering the reward/risk ratio for R&D investments within and between technology life cycles. As life cycles

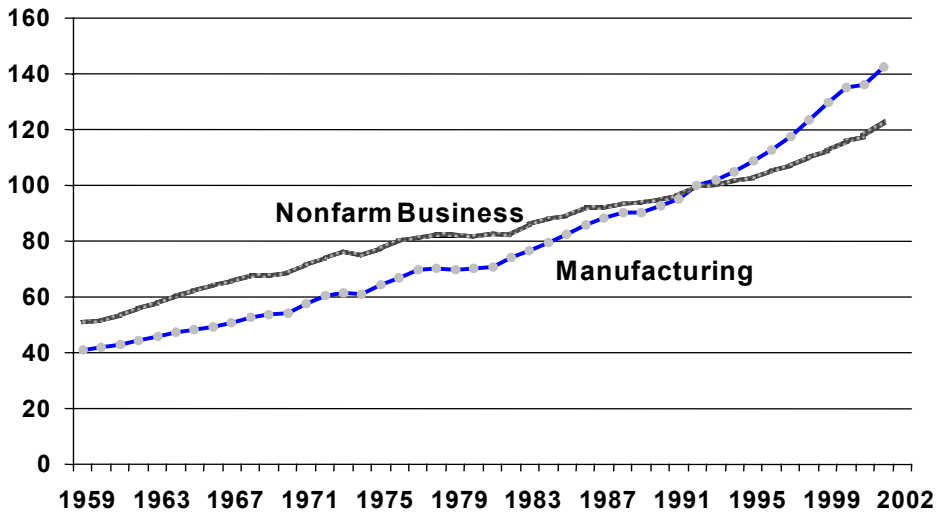
[23] The potential for market spillovers of R&D has been quantified in a forthcoming NIST paper, "Inter-Industry Diffusion of Technology That Results From ATP Projects" (GCR # 03-848).
[24] "On the Importance of Geographic and Technological Proximity for R&D Spillovers: an Empirical Investigation," by Michael J. Orlando, Federal Reserve Bank of Kansas City, July 2000.

compress, R&D at the company level no longer can exist in isolation of a supporting network. Corporations increasingly require access to R&D conducted by other firms in their supply chains and to the broader technology infrastructure provided by a national innovation system. If domestic R&D resources are not available, U.S. companies do not hesitate to form research partnerships with foreign companies, outsource R&D overseas, or directly invest in foreign research facilities. These research relationships often lead to follow-on foreign manufacturing relationships. Thus, the maintenance of an effective domestic R&D network is essential for attracting domestic and foreign R&D funds and subsequent manufacturing, which increases domestic value added and hence economic growth.[25]

C. Manufacturing is the Major Driver of Productivity Growth

Manufacturing has long led U.S. industries in productivity growth. Gains in productivity raise a country's standard of living. In the past fifteen years — which include both years of economic expansion and recession — output per hour in the U.S. private non-farm economy rose at an average annual rate of 1.9 percent. That

Chart 3: Labor Productivity in U.S. Nonfarm Business and Manufacturing
(1992=100)



Source: Bureau of Labor Statistics

[25] "R&D and Long-Term Competitiveness: Manufacturing's Central Role in a Knowledge-Based Economy," by Gregory Tassey, National Institute of Standards and Technology, February 2002, p. 9.

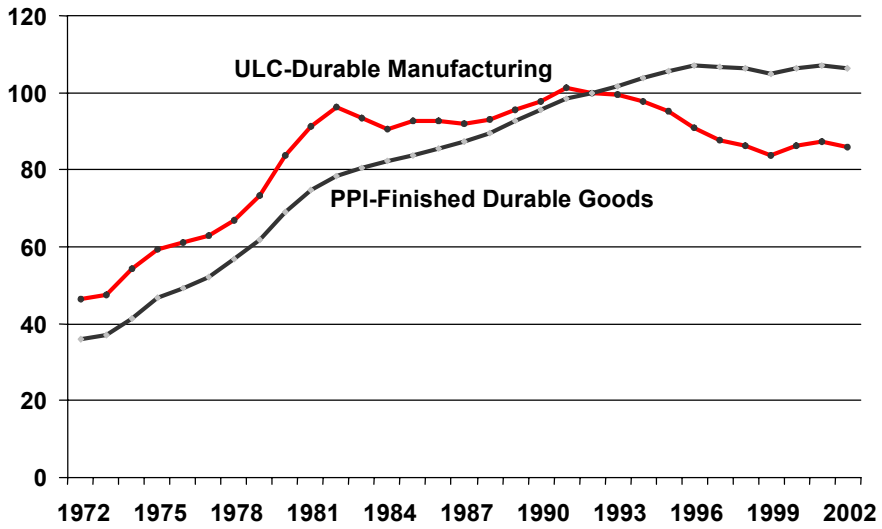
productivity performance was substantially a result of gains in manufacturing labor productivity, which rose 3.1 percent per year.[26]

In the same timeframe, total nonfarm multi-factor productivity — the productivity of labor and capital combined — advanced 0.9 percent annually. The manufacturing sector had an increase of 1.6 percent per year. Durable manufacturing turned in an exceptionally strong multi-factor productivity increase of more than 2 percent per year, reflecting the technological breakthroughs in the manufacture of high-technology electronic goods.

As can be seen in Chart 3, there was a substantial acceleration in labor productivity beginning in the mid-1990s, and multi-factor productivity followed a similar pattern of gains. That acceleration encouraged many analysts, led by the federal Reserve Board, to conclude a new productivity breakthrough had occurred.

The main benefit to manufacturing from this acceleration in productivity was manufacturers' increased ability to compete, as labor costs per unit of output declined. As can be seen in Chart 4, unit labor costs in durable manufacturing have declined in all

Chart 4: Unit Labor Costs in Durable Manufacturing
PPI for Finished Durable Goods
(1992=100)



Source: Bureau of Labor Statistics

but two years since 1991, the end of the last recession, and have shown an average annual decline of 1.5 percent. This has been a major factor in flat and declining prices for manufactured durable goods during this time period. After remaining relatively flat between 1991 and 1997, unit labor costs in the non-durable industries have shown modest increases during the past five years but have still performed better than the private nonfarm business sector as a whole.

These developments helped enable manufacturing wages to rise in line with other wages, 3.3 percent per year, while the price of the goods manufacturers sold increased only about 1 percent per year since 1990. Thus productivity has allowed manufacturing to price competitively in an increasingly global economy.

D. Manufacturing Provides Valuable Jobs

Manufacturing provides well-paying jobs with benefits to its workers. In 2001, salaries and benefits averaged about $54,000 in the manufacturing sector compared to an average of $45,600 for the private sector overall.[27] If one compares workers with the same characteristics, workers in durable manufacturing earned 12 percent more than workers with comparable characteristics in the private sector overall; workers in non-durable manufacturing earned 5 percent more.[28]

Manufacturing offers job opportunities to workers across the educational spectrum — employing more than its relative share of the workforce with no more than a high school diploma, but also employing a large number of college-trained employees. In 2000, manufacturing had on its payrolls 16 percent of the workforce without a college degree, the second largest employer of that group in the country.[29] However, manufacturing also employed 12 percent of the workforce who had at least an

[27] Average compensation per full-time-equivalent employee. Bureau of Economic Analysis, U.S. Department of Commerce.
[28] Based on an analysis of data in the 2000 *Current Population Survey* by JPC.
[29] Retail trade is the largest employer of workers without college degrees. BLS reports that in December 2002 wage levels in manufacturing were $17.33 per hour compared to $9.57 per hour in retail trade.

associate's college degree, the second largest employer among the major industries of that group, as well.[30]

Two factors make the manufacturing sector attractive to workers with all levels of education. One is the pay and benefits, and the other the educational and training opportunities provided by employers. The latest Labor Department surveys on employer training were conducted during the early and mid-1990s. Those surveys indicated over half of manufacturing employees needed training to qualify for their jobs. About 13 percent of the workers received formal job training, 30 percent received informal job training, and 26 percent trained in a school environment.[31] About 38 percent of manufacturing workers also took skill-improvement training, the majority receiving their training through either formal or informal on-the-job training. Manufacturing and infrastructure industries were leaders in the percentage of training time, about 40 percent of formal training time, that was devoted to production, communications and quality training.[32] The focus on production skills in formal training and on-the-job training creates a national pool of skilled craftsmen essential to an industrial economy. However it is accomplished, training provides an important investment in human capital needed for future growth and productivity improvements.

One result of these benefits is that manufacturing sector employees stay with the same firm longer than employees in any other private-sector industry (except mining). This stability is an advantage for the long-run embedded knowledge in the sector's workforce. In 2002, the typical manufacturing employee had 5.5 years of tenure (measured as the median number of years in the job), in contrast to 3.3 years for all employees working in private industry. This was the highest tenure for any major private industry sector of the economy.[33]

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[30] The largest employer of people with less than a college degree is the retail services industry and the largest employer of people with at least an associate's degree is the educational services sector. *Current Population Survey* 2000.

[31] *How Workers Get Their Training: a 1991 Update*, Bureau of Labor Statistics, U.S. Department of Labor, August 1992. Some workers received more than one type of training.

[32] "1995 Survey of Employer Provided Training," Bureau of Labor Statistics, U.S. Department of Labor, Table 5.

[33] The average tenure in manufacturing was 8.7 years in 2000 versus 6.3 years for all private industry workers. *Current Population Survey* 2000.

E. Consumers Benefit From Increased Variety and Quality of Goods

Consumers have benefited greatly from the large selection and quality of manufactured goods available. Consumers also have benefited from competitive pricing, the result of innovations and productivity improvements that manufacturers have effected. The clearest example of this is the contrast between goods inflation and services inflation. From the mid-1980s to the mid-1990s, the gap between core (excluding food and energy) Consumer Price Index services and goods prices averaged about 2 percentage points. Prices of core services increased about 4 percent per year while core goods prices increased about 2 percent per year. That differential has widened over the past five years to more than 3 percentage points. While core service prices have decelerated to the 3 percent range, core goods prices have been virtually flat. That widening corresponds with the acceleration in productivity that was seen in Chart 3 and is driven by the sizable productivity gains in manufacturing and by significant competition in the goods markets. Had that gap not widened but remained the same, consumers would have faced a choice of spending more or purchasing fewer goods, and would have likely done some of both.

Consumers have also benefited from increased manufacturing quality. This spurs new consumer purchases of such goods as cars, refrigerators and electronic equipment even when they already own older models. A 1995 Bureau of Labor Statistics (BLS) study indicates that the quality of goods consumers bought that year accounted for 1.7 percentage points of a total increase of 3.9 percent in the retail prices of those goods and services.[34] If that result is typical, it confirms that quality rather than quantity is the driving force in the growth of U.S. consumer (and probably producer) purchases. For example, it is estimated that the value of the quality improvements in automobiles increased at an annual rate of 2.2% between 1967 and 1998 based on the

[34] "Addressing the Quality Change Issue in the Consumer Price Index," Moulton and Moses, *Brookings Papers on Economic Activity 1997:1*.

quality adjustments that the BLS made to its price index for automobiles during that time period. That implies today's auto is more than twice the car it was in 1967.

One example of quality improvements in manufactured goods is the reduction in the frequency of repair and a reduction in the cost of operation. For example, expenditures on automobile maintenance and repairs per household fell in constant dollar terms from $740 in 1985 to $674 in 1998, a decline of about 0.7 percent per year. However, at that same time the average annual mileage driven per household increased significantly. Consequently, real maintenance costs per mile driven were reduced even more, declining by about 2.5 percent per year. Another example is the reduced operating costs of home appliances. Quality improvements in refrigerators, for example, reduced the annual expenditures needed to operate them by more than 50 percent in real terms between 1981 and 1997.[35]

U.S. consumers have a dizzying array of products from which to choose. Indeed, the average supermarket now carries 49,225 different items – most of which are manufacturers rather than agricultural – compared to 14,145 in 1980.[36] In 2000, more than 9,000 new processed food and beverage items were introduced into supermarkets.[37] This variety of choice is a benefit that cannot be measured in monetary terms; it provides significant advantages and increased levels of satisfaction to the American consumer.

F. Manufacturing Benefits the States

The presence of a manufacturing base contributes to state economic growth through the mechanisms already described for the national economy: linkages to other parts of the economy, well-paying jobs and the benefits associated with investment and R&D spending. Table 1 shows manufacturing employment and manufacturing employment share for each state in early 2003. Manufacturing industries are ubiquitous

[35] See Chapter 4 of "Producing Prosperity-Manufacturing Technology's Unmeasured Role in Economic Expansion," by Joel Popkin and Company for The Association for Manufacturing Technology, September 2000.
[36] Number of Stock Keeping Units (SKUs) in a typical supermarket, Food Marketing Institute.
[37] "New Products and Services," Food Marketing Institute.

in the United States; only eight states and the District of Columbia had 5 percent or less of their employment in manufacturing in 2003. Only Indiana had more than 20 percent of its employment in manufacturing industries. However, 20 states had manufacturing employment shares that ranged between 12–20 percent of their employment base and those states were broadly distributed geographically. Sixteen states had more than 20 percent of their gross state product accounted for by manufacturing during the 1990s. Of those, all but three experienced growth rates in per capita gross product that were above the average for the United States.[38]

Table 1: Manufacturing Employment by State in Descending Order
Thousands of Employees and Manufacturing Employment's Share of Total Employment
March 2003

U.S.	**14,762**	**11.4%**		Oregon	191	12.3%
California	1,590	11.0%		Mississippi	182	16.2%
Texas	925	9.8%		Kansas	178	13.4%
Ohio	863	16.1%		Arizona	176	7.7%
Illinois	740	12.8%		Colorado	157	7.3%
Michigan	735	16.8%		Louisiana	157	8.3%
Pennsylvania	732	13.1%		Maryland	154	6.3%
New York	621	7.5%		Oklahoma	146	9.9%
North Carolina	616	16.1%		Utah	110	10.4%
Indiana	581	20.4%		Nebraska	104	11.6%
Wisconsin	515	18.8%		New Hampshire	81	13.3%
Georgia	454	11.6%		West Virginia	66	9.1%
Tennessee	416	15.6%		Maine	64	10.9%
Florida	395	5.4%		Idaho	61	10.9%
New Jersey	359	9.1%		Rhode Island	61	12.8%
Minnesota	347	13.4%		Nevada	42	4.0%
Massachusetts	336	10.6%		Vermont	38	12.7%
Missouri	312	11.9%		South Dakota	38	10.1%
Virginia	312	9.0%		New Mexico	37	4.8%
Alabama	299	15.9%		Delaware	34	8.3%
South Carolina	280	15.7%		North Dakota	23	7.1%
Kentucky	272	15.4%		Montana	19	4.8%
Washington	268	10.2%		Hawaii	15	2.6%
Iowa	222	15.6%		Alaska	12	4.1%
Arkansas	210	18.3%		Wyoming	9	3.7%
Connecticut	206	12.6%		District of Columbia	3	0.4%

Source: *Current Employment Statistics,* Bureau of Labor Statistics, U.S. Department of Labor
Note: The sum of the state numbers is somewhat lower than the total manufacturing employment reported for the U.S. as a whole in March 2003. This is primarily due to the state numbers being tabulated using a NAICS industrial classification rather than the SIC classification used for the national totals. Under NAICS, the publishing industries are tabulated as a part of the information sector, whereas for the national employment totals publishing is tabulated as part of the manufacturing sector.

[38] Bureau of Economic Analysis, Gross State Product.

The states with the most manufacturing employees are California, Texas, Ohio, Illinois, Michigan and Pennsylvania. High levels of manufacturing employment are also linked to significant ties to export industries. In five of these states, about 20–30 percent of manufacturing employment is tied to the export of manufactured goods and almost 10 percent of total employment is linked to such exports in four of the states. [39]

Manufacturing companies perform the bulk of industry R&D; therefore, it is not surprising that the list of the top 10 states for manufacturing employment also contains seven of the top 10 states performing industry R&D. California, Michigan, New Jersey and Illinois top that list. Three of those states are among the top five states based on the number of manufacturing employees.[40] Eight of the top 10 states for industry R&D expenditures are also among the 10 states with the largest percentage of jobs tied to the export of manufactured goods.

When manufacturing plants are concentrated geographically they are more likely to benefit from R&D spillovers and other externalities. Silicon Valley in California and the high-tech corridor in New England are often cited as places where R&D spillovers are particularly strong. However, benefits can also be generated through other avenues. One example is the Midwestern nexus where manufacturing employment accounts for about 20 percent of private-sector employment. A recent study of the auto industry indicates that "two-thirds of independent supplier plants, 84% of assembler-owned supplier plants, and 58% of assembly plants are clustered within a day's drive of the motor city" and "essentially all of Canada's auto industry is located within 400 miles of Detroit."[41] Such regional agglomeration does not happen by chance. This close proximity of manufacturing plants facilitates the use of more efficient manufacturing

[39] "U.S. Jobs from Exports: 1997 Benchmark Study of Employment Generated by Exports of Manufactured Goods," U.S. Department of Commerce, International Trade Association, 2001. Illinois and Pennsylvania had 7 and 6 percent of their total employment tied to manufactured exports and Pennsylvania had 17% of its manufacturing employment tied to exports.
[40] "Top R&D-Performing States Display Diverse R&D Patterns in 2000," National Science Foundation (NSF 03-303), November 2002.
[41] "Midwest Infrastructure," *Chicago Fed Letter*, July 2002, p4.

processes, such as just-in-time inventory management, and the proximity provides advantages in U.S.-Canadian trade.

Manufacturing has been an important contributor toward tax receipts at all levels of government. During the past 10 years, manufacturing corporations have paid 30–34 percent of all corporate tax payments for state and local taxes, social security and payroll taxes, excise taxes, import and tariff duties, environmental taxes and license taxes.[42] The benefits of manufacturing are recognized by state governments, many of which have developed plans for attracting new manufacturing investments to their states.

[42] Bureau of Economic Analysis, U.S. Department of Commerce, NIPA data.

III. U.S. Manufacturing's Critical Challenges

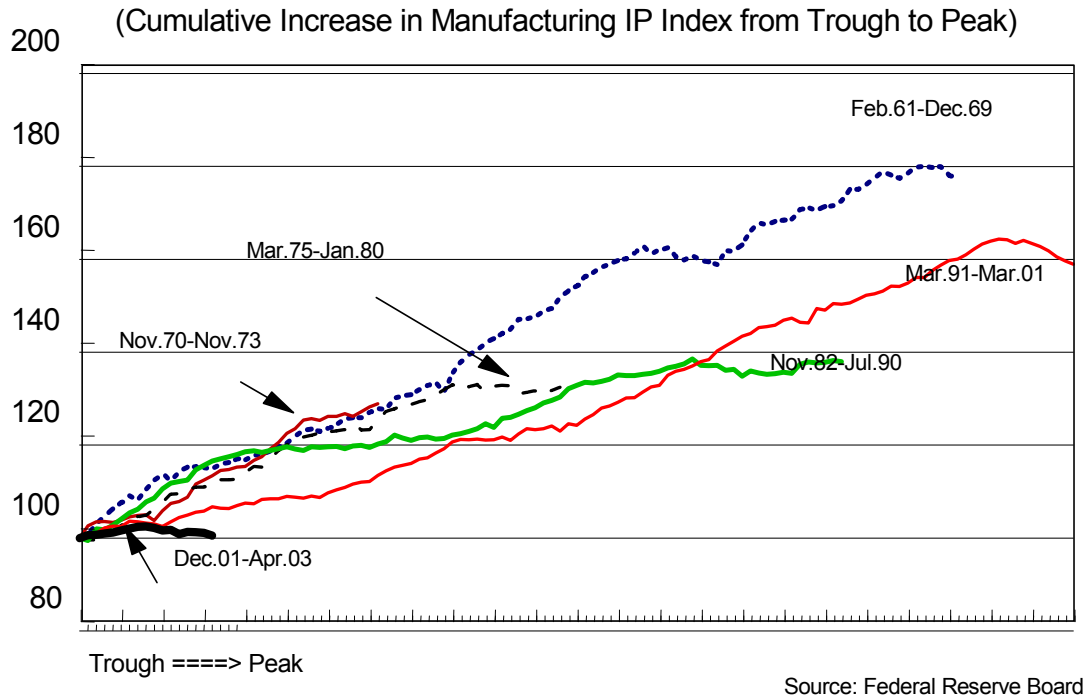
Section II presented the numerous benefits bestowed on the U.S. economy from a strong and growing manufacturing sector. Can those benefits be expected to continue? There is, indeed, cause for grave concern about the future of the inter-linked manufacturing process that has generated such a large share of American prosperity. While no one can determine what the ideal critical mass is to produce the most important benefits from the manufacturing sector, the process by which those benefits are produced clearly requires one. Today there are worrisome signs that mass is endangered. The manufacturing sector has shown few signs of recovery from the 2001 recession and is not exhibiting the same pattern of increased activity that has been observed following prior recessions. In addition, the United States is losing its place as exporter to the world.

A. Manufacturing, the Recession, and the Anemic Recovery

U.S. manufacturing is losing ground. The recession that officially began in 2001 began impacting the manufacturing sector in late 2000. Compared to other business cycles, manufacturing production is far behind its usual pattern of growth for the early part of an expansion. The ramifications from job losses, lost profits and slowing investment are cause for concern in regard to the immediate prospects for the economy's recovery from this recession. If these trends are not reversed they will adversely affect the future economic growth of the United States.

Manufacturing has always played a pivotal role in business cycle developments. As a supplier of goods to other sectors, manufacturing sees new orders fall by more than the decline in the trade sector's sales because new orders are also reduced to allow trade inventory adjustments to take place. This adjustment process continues as finished goods producers pass along order reductions and their inventory realignments to their suppliers. That is the main reason for the large amplitude of the traditional manufacturing cycle.

Chart 5: Manufacturing Industrial Production Growth during Recent Expansions



Source: Federal Reserve Board

The opposite pattern happens during a recovery. Thus, manufacturing tends to lead the way in an economic expansion and provides important momentum to other sectors. But so far in this recovery, that has not happened. Chart 5 compares manufacturing output of this expansion to those of the previous five expansions, as measured by industrial production. The chart shows the growth in output from trough to peak of the respective economic expansions. [43] In the expansions during the 1960s, 1970s and 1980s, manufacturing output rose about 23 percent during the first 17 months of recovery. The recovery from the 1990–91 recession took twice as long to reach that point — over 30 months. That was one reason the early portion of that expansion is often referred to as the "jobless recovery." The recovery in manufacturing output this expansion is lagging behind even the poor start of the 1991 recovery.

[43] Peak and trough months are determined by the National Bureau of Economic Research's Business Cycle Dating Committee. That Committee has determined that the peak of the last expansion, and thus the start of the most current recession was in March 2001. It has not yet determined the date for the trough of the recession. For this analysis, December 2001 has been chosen as the most likely date for the trough month.

Manufacturing output is up less than 1.0 percent over the past 17 months compared with about 7 percent the previous recovery.

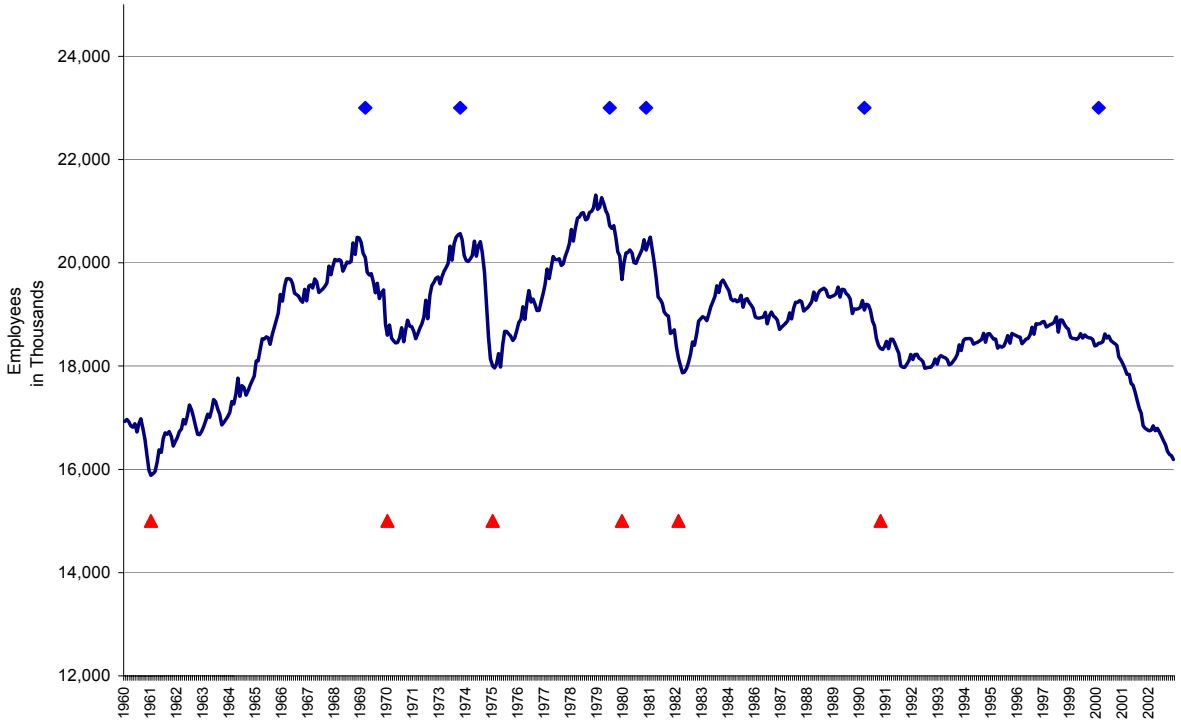
The faster manufacturing grows, the faster the U.S. economy and U.S. standard of living grow. But manufacturing growth slowed systematically in the two decades following the 1960s, when it increased at an annual rate of 4.8 percent. Industrial production increased at an annual rate of 3.0 percent in the 1970s, and only 2.5 percent in the 1980s. In the 1990s the growth trend accelerated almost back to the 1960's rate as new technologies prompted faster growth. However, recent weakness in the manufacturing sector leaves the prospects for the 2000s very unclear.

B. Manufacturing Has Lost a Large Number of Jobs

Manufacturing jobs are always lost during recessions. However, during past recoveries the number of jobs has generally grown. Chart 6 shows total manufacturing jobs along with the peaks and troughs of the business cycle. The peak periods are marked by diamonds at the top of the chart, and the trough months are marked by triangles at the bottom of the chart. Since the late 1970s, each peak has been a bit lower than the previous peaks' high point and during the recovery following the 1990–91 recession, manufacturing job growth showed only modest gains. In contrast to the usual pattern, manufacturing has lost jobs at a significantly faster pace during the last two years. As of early 2003, the number of manufacturing jobs is about equal to the number of jobs at the trough of the 1961 recession. This may be a signal that manufacturing will no longer generate the employment, and its related benefits, the economy has always relied on. In April 2003 manufacturers employed about 16.3 million workers, two-thirds of whom were production workers.[44] Between 1990 and 2000, the year prior to the most recent recession, employment in manufacturing fell by about half a million jobs, declining from 19.1 million to 18.5 million. Since 2000, in stark contrast, manufacturing has lost 2 million jobs, four times the loss in the preceding decade.

[44] *Current Employment Statistics Survey*, U.S. Department of Labor.

Chart 6: Manufacturing Employment, January 1960 to April 2003



Source: Bureau of Labor Standards (CES)

The last time manufacturing experienced 2 million job losses was in the early 1980s when manufacturing jobs declined from 21 million to 18.4 million before recovering slightly toward the end of that decade. During the 1990 recession and its immediate aftermath, manufacturing jobs declined by about 1 million before recovering to 18.8 million in 1998. While there may be some recovery from these low employment levels, it is not apparent in the current employment numbers. Furthermore, since the pattern from the most recent recovery shows lower peak employment levels than the previous one, many of these jobs may be lost forever.

Manufacturing employment has been impacted more than the jobs in the rest of the economy. For the United States as a whole, manufacturing employment as a share of total employment has fallen from 13.2 percent in 2000 to 11.4 percent in early 2003. This decline has been widespread geographically. Every state has seen a decline in

manufacturing's share of total employment. While in 2000 six states had manufacturing shares that exceeded 19 percent of their employment base, by March 2003 only one state had a manufacturing share that high.

One aspect of this rapid decline in manufacturing employment is the focus by manufacturers on core businesses. Business units outside those core areas of competence are spun off or closed, some become separate domestic firms (not all of them in the manufacturing sector) and others move to foreign locations, or the work is outsourced to a foreign firm. This "hollowing out" of industry can have significant impacts beyond the job losses. The movement overseas of manufacturers affects the entire industrial network. As manufacturers relocate overseas, suppliers all the way up the supply chain must make plans to relocate as well.

Plant closures accounted for 50–60 percent of the job displacements in manufacturing for workers with three or more years of tenure during the period from January 1993 through December 2001.[45] That compared with 45–50 percent for the non-manufacturing sectors of the economy. On average each year from 1993 through 1998, 177,000 manufacturing workers with three years or more of tenure lost their jobs due to plant closures. From January 1999 through December 2001 that rate increased to 230,000 workers per year.[46] The rate of reemployment for long-tenured employees (three years or more at their jobs) in manufacturing is also relatively low. Less than half of those workers return to manufacturing jobs; the rate of re-employment in non-durable manufacturing is even lower: only about a quarter of those losing jobs in non-durable manufacturing re-employed in non-durable manufacturing.[47] Long-tenured, full-time manufacturing employees who do find new full-time jobs, in any industry, tend to take a

[45] The reason for plant closures cannot be identified in these surveys. Consequently, all of these job displacements cannot be positively linked to outsourcing overseas. However, many of the industries with increasing import penetration shares are also industries in which a large percentage of the job losses are due to plant closures.

[46] *Displaced Workers Survey*, Bureau of Labor Statistics, U.S. Department of Labor.

[47] These rates cover workers who lost their jobs due to plant closures, lost shifts or slack work. Consequently, the rates of re-employment among workers whose jobs were lost due to plant closures is undoubtedly somewhat lower than these.

pay cut. In 1998, that loss of pay averaged about 10 percent, over twice as large as the average for re-employed workers overall.

C. Implications for Productivity of a Jobless Recovery

As chronicled in Section II, manufacturing productivity has been remarkable.[48] Relatively strong productivity growth has been maintained during the recession. However, that has been due to job cutbacks in manufacturing and other industries. That is not the most beneficial way for an economy to generate productivity growth. Robert J. Samuelson, in a 2003 op-ed piece, stated:

> Over the long run, better productivity signifies higher living standards through new products, technologies and management methods. But at any one time, productivity depends on prevailing economic conditions – which may not be favorable. The present productivity surge reflects bad news more than good: layoffs, bankruptcies and cutbacks. The ruthless elimination of the least efficient plants and companies may improve productivity. But it doesn't necessarily signal a robust recovery.[49]

Samuelson's analysis suggests that the most recent gains in productivity may be masking long-term damage to the process through which economic gains are made. Once the manufacturing "heart" shrinks to the point that it can no longer support the complex inter-linked process of innovation and investment, the method by which productivity gains are translated into long-term gains in prosperity is lost. Unfortunately, there is no clear diagnostic test whereby that loss of critical mass can be clearly identified – only a myriad of symptoms that a potential danger point has been reached.

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[48] "Based on historical experience, it seems improbable that all of the large rise in multifactor productivity could be attributed to cyclical or transitory factors. Conversely, it seems very unlikely that all of the increase in the growth of productivity could be attributed to structural influences. The truth, presumably, lies between these two extremes, but where has yet to be determined. At minimum, however, it seems reasonable to conclude that the step-up in the pace of structural productivity growth that occurred in the latter part of the 1990s has not, as yet, faltered. Indeed, high growth of productivity over the past year merely extends recent experience. Over the past seven years, output per hour has been growing at an annual rate of more than 2-1/2 percent, on average, compared with a rate of roughly 1-1/2 percent during the preceding two decades. Although we cannot know with certainty until the books are closed, the growth of productivity since 1995 appears to be among the largest in decades." Alan Greenspan in a speech at the American Enterprise Institute, October 23, 2002.

[49] "Economic Darwinism", Robert J. Samuelson, *The Washington Post*, March 19, 2003.

D. U.S. Manufacturing Losing Ground in Global Trade

The United States continues to be the largest supplier of manufactured exports to the world; however, there are troubling developments in the merchandise trade sector that U.S. leadership in export trade has been strongly challenged.

Despite the growth in goods exports, the merchandise trade deficit has been negative since 1976. Goods exports as a share of U.S. GDP peaked at about 8 percent in late 1997 but has retreated to about 6 percent since then. This reflects declining goods exports in 1998 (due to the Asian currency crisis), some recovery in growth in the 1999–2000 period, and then a sharp decline in goods exports in 2001 and 2002. This last decline partially reflects the impact of the recession on our trading partners and of 9/11; but that is not the only cause. While the decline in U.S. exports in 2001 corresponded to a decline in total world trade, the same cannot be said for 2002. World merchandise trade increased 4 percent last year, while U.S. merchandise exports continued to decline.[50] Consequently, after two decades of relative stability, the U.S. share of world manufactured exports declined from 13.5 percent of the world total in 2001 to about 11 percent in 2002. That reflects a worsening of the U.S. position vis-à-vis other nations producing manufactured exports. This weakening of the U.S. goods exports corresponds to a worsening of the trade deficit relative to GDP. [51]

The strong U.S. dollar overseas is blamed for handicapping export growth and encouraging the growth of imports. The recent weakening of the dollar in many countries – it has fallen 8 percent from its peak in February 2002 – should be considered helpful to U.S. goods manufacturers. A rise in their exports should follow. But the balance of trade impact of the dollar's recent decline will probably not be as large as some have anticipated.

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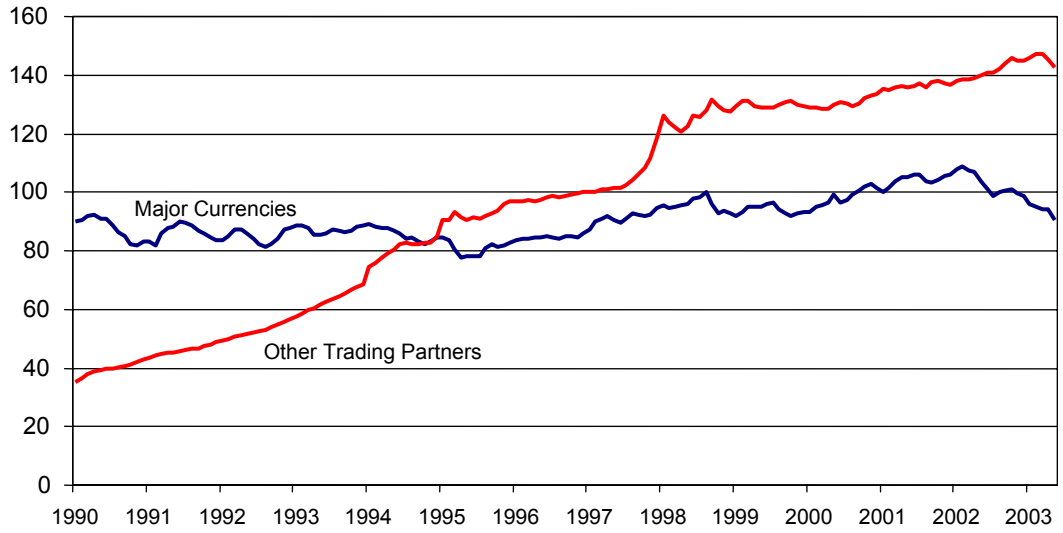
[50] "Trade Recovered in 2002, but Uncertainty Continues," WTO, April 2003.

[51] The large current account trade deficit in the United States is sustainable only as long as foreign investors are willing to continue to buy assets in the United States in the form of stocks and bonds. The United States's strong economic base and stable political situation have been the basis for attracting that investment in the past. However, there are never any guarantees that foreign investors will continue to accumulate dollar holdings in their foreign exchange reserves at the same rate they have in the past.

That is because the decline is being driven by the 17 percent depreciation of the dollar against "major" currencies of the world — those that are traded on exchanges outside of their own countries. But those countries only account for 56 percent of U.S. trade. The other 44 percent reflects trade with countries, such as China, whose currencies are not defined as major currencies. If one looks at exchange rates applicable to the other 44 percent of U.S. trade, as shown in Chart 7, it is clear that the dollar has been increasing in value against them: 2 percent in the past year.[52] Imports from those countries account for 46.5 percent of U.S. imports, but only 40.7 percent of U.S. exports. The differential for China is even larger. China bought 3 percent of U.S. exports in 2002, but was the source of 11 percent of U.S. imports; therefore, trade with China accounted for 21.9 percent of the 2002 U.S. merchandise trade deficit.[53] In the absence of the Chinese government's intervention in the value of its currency against the dollar – some analysts estimate it is valued 40 percent higher than its market value

Chart 7: Federal Reserve's Nominal Dollar Indexes



[52] Many of the currencies in this index are pegged to the dollar and the exchange rate for those currencies show little month-to-month variation. The other currencies in the index tend to devalue against the dollar.
[53] In general China's exports and imports boomed in 2002, each growing in excess of 20 percent overall. WTO figures show China was virtually tied with France for the spot of fourth largest exporter of merchandise in the world in 2002

– U.S. exports to China would presumably be higher and imports from China lower.

Service exports have grown significantly in recent years, but were still less than half the size of goods exports in 2002. Consequently, the United States cannot depend solely on trade in services to offset the serious decline in goods exports. In addition, U.S. providers of business services are facing increasingly strong competition as foreign producers of services begin to staff U.S. call centers and provide programming services to U.S. companies. These jobs represent U.S. service imports and offset U.S. service exports. Consequently, the solution to the trade deficit is unlikely to be found solely with service sector exports.

U.S. imports of merchandise account for one-fifth of world trade.[54] Imports have been a positive force in the United States because the influx of inexpensive goods has helped keep prices down and encourage consumer spending. But when trade becomes too one-sided, it can slow economic growth. As a recent *Business Week* article states, "Real GDP… is a tally of domestic output, so when a bigger chunk of spending is satisfied by foreign suppliers, it's a drag on economic growth, especially in the manufacturing sector."[55] Consequently, it is important for the United States to maintain its ability to produce new and better goods and services for export.

Part of the growth in the merchandise trade deficit can be attributed to the growing purchases by U.S. "Original Equipment Manufacturers" (OEMs) of foreign-produced parts and components for their products. A measure of this hollowing out of the supply chain can be found in the statistics on "related party trade" – that is, imports to the United States from U.S.-owned foreign factories or from foreign companies to their U.S. affiliates. In 2001, the Department of Commerce estimated that $526 billion, or 47 percent of all U.S. merchandise imports, fell under this category of trade.[56] The links between manufacturers and other sectors of the economy lead to broader impacts on the economy than just the loss of each manufacturing plant. It also reduces the

[54] "World Trade Developments in 2001 and Prospects for 2002," WTO, October 2002.
[55] "U.S.: Imports Get a Bigger Piece of the American Pie," James Cooper and Kathleen Madigan, *Business Week*, February 3, 2003.
[56] "U.S. Goods Trade: Imports and Exports by Related Parties, 2001," U.S. Department of Commerce, May 2002.

need for the support services and infrastructure improvements that would be necessary to support those manufacturing activities if they were preformed in the United States.

In considering the competitiveness of U.S. manufactured goods in world markets, the costs of maintaining one of the most environmentally sound processes in the world must be noted. U.S. manufacturers' clean production processes and safer products are designed for domestic and world consumption, which means they often compete with products produced under less environmentally sound processes. This dual production is not costless to the manufacturing sector. In 1999, the direct cost to the manufacturing sector for new pollution abatement equipment was $4.4 billion, 76 percent of all such expenditures by U.S. industries. In addition, manufacturers spent $10.2 billion in operating costs for ongoing abatement activities, 86 percent of the total amount spent by all industries.[57] Together those costs equaled almost 6 percent of the before-tax net income of manufacturing companies in 1999. Beyond these direct costs for pollution abatement equipment, its operation and maintenance, there are other costs associated with meeting all federal environmental regulations. Estimates of those costs vary but a recent study done for the SBA estimates that the total cost paid by U.S. manufacturers to comply with those regulations is almost $70 billion annually.[58]

The role of the United States in world trade is enhanced by the ability to innovate. One of the more important U.S. service exports takes the form of payments for using a U.S. patent or other form of intellectual property; those payments currently make up about 13 percent of service exports. Almost 75 percent of the payments for intellectual property are between affiliated companies; U.S. firms; and companies they own or controls overseas. While this share has declined slightly since the mid-1980s it is one indication of the internationalization of U.S. manufacturing know-how. The allocation of patents in the United States provides further information on the processes of innovation in the goods-producing industries. Foreign-origin patents represented about 45 percent of all patents granted in the United States in the mid-1990s, the vast majority of which

[57] "Pollution Abatement Costs and Expenditures: 1999," Census Bureau, November 2002, Table 1.
[58] "The Impact of Regulatory Costs on Small Firms," W. Mark Crain and Thomas Hopkins, Small Business Administration, 2001.

are owned by foreign corporations.[59] While U.S. inventors are still awarded a growing share of all U.S. patents, it is noteworthy that, based on the number of patents awarded, only three American corporations were in the top 10 companies ranked by numbers of new patents in 1999. The remaining corporations were Japanese- or Korean-owned. Compare this to the number of patents awarded during the entire 1977–1996 time period, when over half of that top 10 list of patenting corporations were U.S. companies.

Recent empirical research has found a link between U.S. wages and its share of patents. Among the findings of that paper is "a rise in the share of the United States in world innovation or in U.S. patents is associated with an increase in U.S. wages, while, an increase in foreign shares is usually associated with a decrease [in U.S. wages]."[60]

E. U.S. Manufacturing Investment in Capital and R&D at Risk

The ability of the United States to continue to innovate and produce product and process improvements is also showing signs of deterioration. Manufacturing's share of capital investment has begun to slip. In 1999 its share of equipment and software purchases fell below 20 percent for the first time, and averaged only 17 percent during the 1999–2001 period.

Manufacturers accounted for 62 percent of private R&D in 2000 — $124 billion — and manufacturers financed 90 percent of that total themselves.[61] However, the $11 billion increase in R&D spending between 2000 and 2002 represents only half the recent pace of R&D spending. In real terms, spending on R&D by all of private industry barely changed in 2002. And the National Science Foundation reports that manufacturing R&D input has barely grown for the past decade, only 5.6 percent (0.5 percent per year) in the 1989–1999 period.[62] So while at 62 percent the manufacturing share of industry R&D is still high, that is much weaker than past performance.

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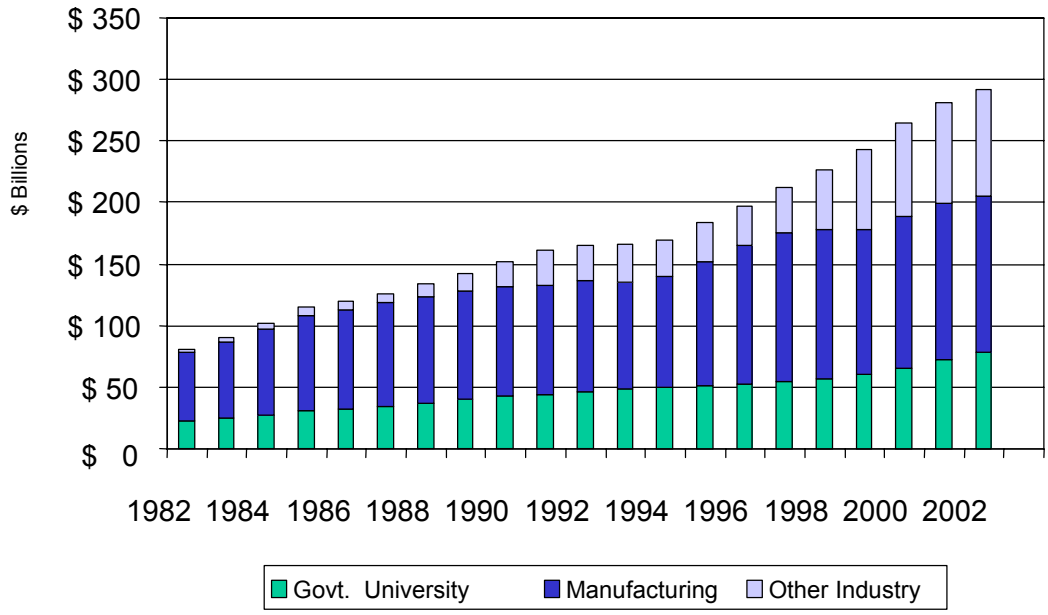
[59] *Science & Engineering Indicators 2002*, National Science Foundation, p. 6-21.
[60] "Technology, Trade, and Wages," NBER Working Paper 5940, by James D. Adams, 1997, p. 28.
[61] The remaining funds come from federal government sources. "U.S. Industrial R&D expenditures and R&D-to-Sales Ratio Reach Historical Highs in 2000," National Science Foundation *InfoBrief* (NSF03-306), December 2002.
[62] The price index NSF uses is probably closer to an input price index (wages and salaries, equipment, supplies, etc.) than a proxy for an output price index.

Chart 8: R&D Expenditures by Performing Sector



Source: National Science Foundation

Manufacturing's share was 80 percent just 10 years ago and 95 percent 20 years ago. At first glance, one could conclude this is a result of the rapid growth of the services sector, and as Chart 8 shows there is an increase in non-manufacturing R&D.[63] However, the slowdown in the real growth of total R&D and the slowdown in goods-related R&D will impact the beneficial effects of the externalities that accompany new innovations in manufacturing.

There are also indications that the R&D expenditures of the United States as a share of the total R&D conducted by industrialized countries have begun to shrink. In 1984, the United States accounted for about 48 percent of total OECD R&D expenditures (in real terms) but by 1998 that share had fallen to less than 44 percent. And while the United States still spends more, by far, on R&D than any other OECD nation, it ranks only fifth in the world when ranked on R&D expenditures as a percent of GDP. [64]

[63] Detailed tables on nonmanufacturing R&D indicate a large proportion of the expenditures take place in the network industries, trade and information services.
[64] *Science and Engineering Indicators--2002*, National Science Foundation, Chapter 4.

In his book *The Free-Market Innovation Machine*, William Baumol discusses the importance of the competitive market mechanism in encouraging firms to devote a steady stream of expenditures to R&D. This, in and of itself, promotes growth in GDP. "[A] steady flow of innovation does not mean that GDP remains constant. Rather, a level flow of innovation can result in steady growth of the economy's output."[65] That comes from three main processes: 1) the cumulative character of many innovations — called innovation breeding where one new idea suggests another new idea; 2) the public-good property of innovation — often thought of as a spillover effect; and 3) the accelerator feature of innovation — innovation growth plus the productivity impacts from that innovation. Assuming Baumol's model is correct, the current decline in R&D expenditures bodes ill for the continued growth of the U.S. economy.

If the U.S. manufacturing base shrinks too much, it promotes a shift in R&D and investment to other global centers where the critical mass necessary to conduct it exists and is growing. If this happens, a decline in the U.S. long-term economic growth rate is all but assured.

The ability to fund new R&D spending comes largely from the profits that a company can plow back into its business. Thus, the available cash flow of manufacturing firms is closely linked to their ability to perform R&D work as well as make capital investments. One measure of the cash flow available for such investments is the depreciation charges of a company, plus the profits it retains rather than distributes as dividends to its shareholders.[66] In the late 1980s manufacturing accounted for almost 40 percent of all corporate cash flow in the U.S. economy. Between 1999 and 2001 alone, this measure of manufacturing corporate cash flow fell by almost 20 percent, to 25 percent of total corporate cash flow in the United States. This puts severe limitations on companies' abilities to make the necessary investments

[65] Baumol, p. 51.

[66] In the early 1990s, manufacturing was paying out almost 30 percent of all corporate dividend payments to shareholders in addition to retaining enough earnings to fund its investment programs. Manufacturing's share of dividend payments declined to about 20 percent of the total corporate dividend payments in 2001. Bureau of Economic Analysis, U.S. Department of Commerce.

to spur future innovations and growth. Cash flow varies with the business cycle; the recession is one of the reasons for the recent slowdown in R&D.

While cyclical variations in cash flow and R&D are damaging to the creation of a constant stream of innovations, two other factors, longer term in nature, also temper private R&D spending. The first factor is the inability of producers to recover the fruits of all of their spending through the prices they charge for their innovations.[67] It is widely agreed that firms doing R&D do not capture all or even most of their investment through the price mechanism. The existence of these essentially "free" spillovers means the social return from R&D exceeds the private return. That can lead to a reluctance by firms to undertake some higher-risk projects. Another example of social returns being greater than private returns is related to the scope of the benefits from R&D. A single firm is unlikely to focus on the full scope of the possible uses of innovations resulting from its R&D. This may be increasingly true as firms focus on producing results from their R&D that will primarily benefit their relatively narrow core businesses.

In recognition of these instances where social returns to R&D are higher than the private returns, the federal government has put tax credits in place for research activities as part of the general business tax credit. In 1999, manufacturing received 74 percent of the benefit of the research activity tax credit and reduced its federal tax liability by $3.9 billion. However, that was only about 4 percent of its total federal income tax liability and about 3 percent of the total amount the manufacturing sector spent on R&D.

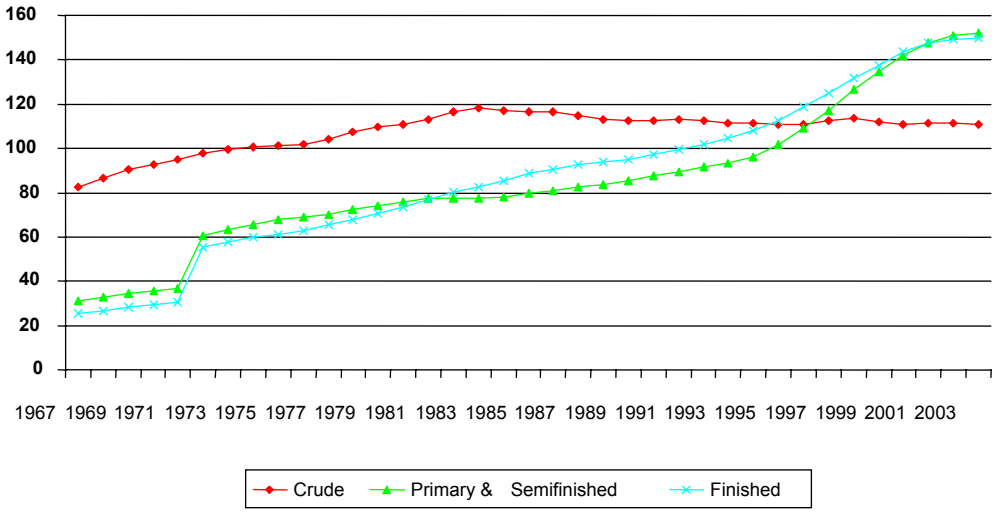
F. Manufacturing Capacity is Not Growing and Its Usage Has Dropped

Investment in new capacity is the hallmark of a growing industry that is optimistic about the future. Overall, U.S. manufacturing capacity has grown fairly steadily since the early 1980s (see Chart 9). But that masks the onset in 1980 of a decline in the United States's capacity to process crude materials for subsequent transformations by

[67] "The Search for R&D Spillovers," Zvi Griliches, NBER Working Paper no. 3768, July 1991.

the rest of the manufacturing sector.[68] The mining industry is a case in point: domestic exploration and productive capacity have declined significantly over the past two decades. The number of U.S. metal and non-metal mines has declined by 61 percent since 1980.[69] As a result, the United States has become more dependent on foreign nations to supply these raw materials: the reliance of the United States on mineral imports has risen nearly sevenfold in terms of value. The United States now imports over 50 percent of 37 mineral commodities, all of which are important for manufacturing and strategic military uses.[70] This increases the vulnerability of U.S. manufacturers to supply disruptions and the possibility of sudden and sharp price increases. Some of the decline reflects dwindling U.S. petroleum and mineral resources. But the decline also reflects the fact that policies have discouraged the development of resources in the United States. As a result, mineral and crude processing capacity is being located closer to the growing customer base in other countries, particularly those in eastern Asia.

Chart 9: Manufacturing Capacity by Stage of Process



Source: Federal Reserve Board

[68] See "Bottleneck Inflation and Growth," Joel Popkin, *The Rising Tide,* edited by Jerry Jasinowski, John Wiley & Sons, 1998.
[69] 2001 U.S. Mine Safety and Health Administration, "Injury Experience in Coal, Metal, Stone, Sand, Gravel, and Non-Metal Mining," Table 2, p. 16.
[70] U.S. Geological Survey, "Mineral Commodities Summaries 2003," p. 5.

The smaller the U.S. demand for locally produced finished goods, the less likely new capacity will locate here. Notwithstanding the leveling-off of crude material capacity growth, U.S. manufacturing capacity growth has been sustained by the growth of plants producing intermediate and finished goods. However, since 2000 finished and semi-finished goods capacity has not grown.[71] Furthermore, the utilization of the capacity available in the United States is quite low, especially toward the end of the manufacturing chain. In April 2003 the capacity utilization rate for primary and semi-finished goods production was at 76.5 percent, slightly below its low point during the 1990–91 recession. However, capacity utilization for finished goods is only 70 percent, a full 7 percentage points below its lowest point during the 1990–91 recession.

Restructuring of industries and a loss of market share in some industries is a part of the dynamic economic process. But a loss of manufacturing capacity across the board is a signal of a potentially more serious problem that has implications for long-term economic prosperity.

G. Manufacturing Faces a Skills Shortage

The manufacturing sector has been a leader in teaching and improving the skills of its workforce, much of it through on-the-job-training. While companies across all industries are concerned about a lack of basic educational skills in their workforce, manufacturing faces the additional concern of a potential shortage of workers with the specific manufacturing skills needed to produce their products. The improvements of the skills and knowledge of the workforce is as important to achieving future gains in productivity as is the production of new and better capital equipment. Both are vital to the long-term growth process.

Dr. Beth Buehlmann of the Center for Workforce Preparation addressed the general skills shortage facing employers in recent testimony before Congress:

[71] Capacity by stage of process, Federal Reserve Board.

> In January 2002, data from a survey of over 1500 employers, confirmed similar results — 73 percent experienced very or somewhat severe conditions when trying to hire qualified workers, and 70 percent said that the workers had poor, wrong or no skills to meet business needs. The third CWP survey, conducted this January of 3700 employers from 80 communities across 34 states, found that just over 50 percent said it was 'very hard or hard' to find workers with the skills that they need. One out of eight employers said that applicants needed assistance with training of basic skills — reading, writing, math and communications. What these results indicate is that even in a slow economy employers are having difficulty finding skilled workers. [72]

In 2001, the National Association of Manufacturers (NAM) conducted a study of workforce issues in the manufacturing sector. The survey found that more than 80 percent of manufacturers reported a "moderate to serious" shortage of qualified job applicants — even as manufacturers were reducing workforces. The study notes that "what manufacturing is facing is not a lack of employees, but a shortfall of highly qualified employees with specific educational backgrounds and skill."[73] This problem is felt especially among small firms where, at times, it has impacted a company's ability to accept work.

The flip side of this challenge is the growing scarcity of entry-level openings in manufacturing. While the average age of workers in manufacturing is only slightly higher than it is for the nonfarm economy as a whole — 41 years compared to 38 years — the distribution of workers is noticeably different. In 2000, 19 percent of workers in manufacturing industries were below the age of 30, whereas for the economy as a whole, 28 percent of workers were younger than 30.[74] This reflects the lack of job growth in the manufacturing sector in recent years but also presages a potential skill shortage for the future. When the older manufacturing workers retire there may not be anyone to replace them since there has not been a steady stream of younger workers encouraged to enter the pipeline and gain the important job-specific skills.

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[72] Testimony before the Subcommittee on 21st Century Competitiveness, Committee on Education and the Workforce, U.S. House of Representatives, March 4, 2003.
[73] "The Skills Gap 2001: Manufacturers Confront Persistent Skills Shortages in an Uncertain Economy," National Association of Manufacturers, 2001, p. 3.
[74] Calculations from the 2000 *Current Population Survey*

In a May 2003 *Industry Week* article discussing the future shortage of skilled workers, futurist Roger Herman stated, "The manufacturing jobs that are going to be available are going to be more sophisticated than 'traditional' manufacturing sector jobs." United Technologies has embarked on a major training program for its front-line supervisors because, as its chief learning officer states, "[A] lot of what we are doing is more sophisticated than basic metal-bending. It is costly to lose people, and it is very costly to under-utilize them…. But given that we expect to have less people going forward than we have today, we do spend a lot of time on the issues of quality of what happens on the factory floor and productivity," a comment that underscores the difficulties of companies that are balancing job reductions with their skill needs of the future.[75]

[75] "The Next Crisis: Too Few Workers," John S. McClenahen, *Industry Week*, May 1, 2003.

IV. CONCLUSION

This analysis has shown the benefits that the manufacturing sector provides the whole U.S. economy — from businesses and households to federal and state governments. It has also described the manufacturing-centered innovation process — often just below the statistical radar screen — that is the source of these benefits.

The analysis has also identified troublesome signs that the process through which manufacturing has generated those benefits may be deteriorating. Some of those signs are:

- the manufacturing recovery during the current economic expansion is unusually anemic compared to past expansions;
- there has been an exceptionally rapid decline in manufacturing jobs and with their loss, the potential loss of the skills, education and training of the workforce that promotes productivity growth;
- there are signs that the manufacturing sector may be unable to maintain the pace of its R&D spending, adjusted for inflation;
- current increases in productivity may reflect only downsizing and hide a fundamental slowdown in its trend rate of growth;
- the United States is losing ground in world merchandise trade, particularly vis-à-vis countries whose currency and other policies discourage imports; and
- parts of the U.S. manufacturing sector, such as those that produce raw and primary products, are no longer building new facilities here.

These are signs that dramatic change is underway. The question is whether the change is cyclical or will it become the long-term trend. A change in trend will be, like most structural change, difficult to detect. In fact, it may only be possible to identify the change after it has happened. At that point it could be governed by forces that could be difficult to reverse.

The success of the U.S. manufacturing sector requires a certain mass to be sustainable. This mass must be large enough to encourage investment in R&D

domestically, conducted by our scientists, and to encourage U.S. business to invest in capital goods and human capital here in the United States. Once that mass has diminished below its critical value, the process by which prosperity has been generated may never be recovered. If that is permitted to occur, the growth rate of the U.S. economy may drop to half its historical average.

This white paper is the second in a series of publications for the NAM Campaign for Growth and Manufacturing Renewal.

Council of Manufacturing Associations

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