ENGINES OF GROWTH

MANUFACTURING INDUSTRIES IN THE U.S. ECONOMY

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PREFACE

Analyses by the Economics and Statistics Administration aim to explain changes in the structure of U.S. industries and firms that affect the nation's overall economic performance. Contention about the economic importance of manufacturing is a central strand of American history. Muted in much of the current century, it emerged again in recent decades as global competition challenged U.S. manufacturing leadership and concern arose that America was deindustrializing. Today, as U.S. manufacturing industries reassert themselves, the idea that manufacturing is especially important to the nation's economic health has become an article of popular belief and an axiom of public policy. For this reason alone, it is worth reviewing the relevant evidence.

This assessment of the role of manufacturing industries in the U.S. economy was prepared by ESA's Office of Policy Development. Kan Young, Dennis Pastore, Gerald Moody, Sandra Cooke, Donald Dalton, Susan LaPorte, John Tschetter, Pamela Nacci, and John Dahl conducted key portions of the supporting research with the guidance and participation of Gurmukh Gill. Warren Farb and Frederick Knickerbocker provided valuable advice. Jeffrey Mayer wrote the final report.

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SUMMARY

This study assesses the widely-held belief that manufacturing industries are uniquely important to the process of national economic growth. The study's related purpose is to describe structural changes in the U.S. manufacturing sector and the organization of U.S. manufacturing firms that are helping to determine the pace of economic growth and the creation of economic opportunity. Taken together, these changes comprise the new face of American manufacturing.

Manufacturing and National Economic Growth

Part I of this study finds that manufacturing industries *do* have special growth-inducing properties. More than other industries, they allow specialization in the production process and they develop technology and disseminate it throughout the economy.

Theoretical support for this conclusion comes from an economics literature that stretches back through Alfred Marshall to Adam Smith, and forward in this century to Allyn Young, Nicholas Kaldor and others. Evidence is embedded in an expanding body of research showing that manufacturing industries are the economy's most prolific generators and disseminators of technology and that this function is a predominant influence on overall output and productivity growth. In this regard, manufacturing industries are properly described as engines of economic growth.

Further evidence comes from official estimates of interindustry input-output and employment relationships indicating that, compared with nonmanufacturing industries, manufacturing involves more numerous and varied inputs of goods and services and cultivates a greater variety of production skills. Simply put, manufacturing exercises the economy more broadly than other kinds of production activity.

The New Face of American Manufacturing

The new face of American manufacturing reflects a process of relentless, technology-driven change in the composition of production, the quantities and mix of skills required, and the organization of U.S. manufacturing firms. These changes, which constitute the structure and substance of the growth process itself, are examined in Part II.

Change in the Composition of Output

Recent experience shows that manufacturing industries do not grow stronger (or weaker) together, in time with some general rhythm of economic history. Rather, growth is concentrated in a relatively limited group of industries that gain output share quickly, displacing predecessors and creating new venues for enterprise and employment. The most dramatic of these changes reflect major advances in product and process technology—e.g., in recent decades, the emergence and explosive growth of the computer and related industries, and the substitution of plastics for steel in auto production.

Change in the Composition of Employment

Though manufacturing industries have supplied a relatively constant share of GDP for half a century, the direct link between growth in manufacturing output and the spread of economic opportunity in America is now more tenuous. First, manufacturing accounts for a steadily declining share of total U.S. employment. Second, compared with the 1960s, proportionately fewer manufacturing jobs are concentrated in blue-collar categories. Moreover, erosion in the average wage of manufacturing workers relative to service workers contradicts the common assumption that any manufacturing job is, by definition, a *good job*.

Manufacturing employment declines are not direct consequences of high productivity growth and innovation. In many U.S. manufacturing industries that added workers during 1977-87, any short-term job displacement because of productivity gains was more than offset by increased final demand—possibly the result of lower costs. Also, despite rapid declines in unit labor requirements, many of these industries added jobs by becoming more important suppliers to other industries—i.e., because of changes in production technology.

Change in Corporate Structure

At every stage of modern economic history, aggressive companies have energized the growth process by organizing to exploit production efficiencies inherent in new technology. The organization that a century ago best exploited advances in mechanical technology (e.g., steam power, direct reduction of metals) was typically large, hierarchically organized, and capital-intense. In recent decades, however, dramatic changes—especially the intensification of global competition and epochal advances in information technology—have begun to favor organizations that are smaller, flatter, and more flexible than their predecessors.

Evidence of the new era has begun to appear in official data. On average, manufacturing establishments are smaller than they were ten years ago. A decline in the relative importance of white collar manufacturing employment since 1990 suggests that they are

also flatter—that companies are dismantling management hierarchies originally built to process, verify, and distribute information.

In addition, anecdotal evidence suggests that the information revolution has spawned new systems of networked production in which small specialized firms use shared information to coordinate their activities, simulating the performance of much larger integrated companies. Such networks have the potential to transform the character of business competition from a contest of scale-driven broadly-focused bureaucracies to a contest of highly specialized firms that create value by leveraging world class skills into commanding positions in precisely defined intermediate and final markets.

Addendum on the Importance of a Strong Domestic Manufacturing Base

Evidence that manufacturing industries play a special role in the growth process leaves unanswered the question of whether the benefit of goods production to any nation's economy is diminished when the production happens off shore. Why, for example, should the productivity enhancing effects of an inventory tracking system depend on the nationality of the operating hardware? An addendum to Part II examines two compelling common-sense answers to this question: first, that a strong domestic manufacturing base is essential to balanced trade; and second, that manufacturing industries are geographically linked to high-value added services. Neither answer is definitive.

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INTRODUCTION

This study of manufacturing industries is part of a continuing effort by the Economics and Statistics Administration to explain changes in the structure of U.S. industries and firms that affect the nation's overall growth rate.

Focusing on what happens in industries and firms is only one of several ways to study and explain economic growth. A more traditional approach, for example, explains growth mainly as an accretion of general factors of production—i.e., labor, natural resources, capital, and technical knowledge. This model makes little explicit allowance for the possibility that changes in the composition of industrial activity or firm structure may also help to determine the rate of economic growth.[1]

A second model—one more consistent with the perspective of this study—explains growth as a process of relentless, technology-driven change in which industries gain output share quickly, displacing predecessors and creating new venues for entrepreneurship and employment. In contrast to the traditional explanation, this second approach sets technologies and industries in sharp relief and makes the composition of economic activity a key determinant of overall performance.[2]

A third approach links economic growth to firm structure.[3] In this view, technological development and the emergence of new products and industries frame the growth process. But the substance of that process is what firms do—how they organize to exploit new product and process technologies. From this perspective, U.S. economic history in the industrial era has had two phases: one, extending from the 1880s to the middle decades of this century, when advances in product and process technology favored large scale, hierarchical organization, and heavy investment in capital equipment; and a second, dating from the early 1980s, when the pervasive application of information technology began to dictate new corporate structures and strategies. Part II focuses especially on these changes.

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[1] See, for example, Dale W. Jorgenson, et al., Productivity and U.S. Economic Growth (Harvard University Press; 1987).

[2] See Joseph Schumpeter, Capitalism, Socialism, and Democracy (Harper & Brothers; New York, 1942), 1975 edition, especially Ch. VII, "The Process of Creative Destruction."

[3] See Alfred D. Chandler, Jr. Scale and Scope—The Dynamics of Industrial Capitalism (Harvard University Press; 1990); also David Teece, "The Dynamics of Industrial Capitalism: Perspectives on Alfred Chandler's Scale and Scope," Journal of Economic Literature, XXXI (March 1993), 199-225.

Why Study Manufacturing?

Curiosity about the growth process leads inevitably to manufacturing. The idea that healthy domestic manufacturing industries are essential to national prosperity has been a powerful influence on European and U.S. economists and politicians since the dawn of the industrial era.[4]

The idea endures in part because it seems self-evident. In all of the industrially advanced countries before 1960, and in the newly industrial countries of the post-1960 period, the development of indigenous manufacturing capability has been an invariable complement of rapidly increasing output growth.

The issue for policymakers in developed countries is whether manufacturing industries continue to function as engines of growth when economies mature. Manufacturing now accounts for a declining share of output and employment in all advanced industrial countries except Japan; yet rates of economic growth in these countries have not varied measurably from historic trends. Nonetheless, in important analytic and policy circles, the conviction that manufacturing matters more than other industries seems unshaken. Assessing the evidence for this conviction is a major purpose of this study.

Another reason to study manufacturing is that since the 1960s and 1970s, the sector has been a scene of fundamental changes in the composition of output and employment and in the structure and operating strategies of manufacturing corporations. Explaining these changes—describing the new face of American manufacturing—is the study's second major purpose.

The discussion is divided in two parts: (i) an assessment of the function of manufacturing industries in the growth process; and (ii) an account of continuing structural change in manufacturing industries and firms An addendum to Part II examines the question of whether the economic benefits of manufacturing are greater in countries that preserve substantial on-shore production capacity.

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[4]See Alexander Ha (Columbia University Press, 1966), 262, 290-91; especially 291: "Not only the wealth; but the independence and security of a Country, appear to be materially connected with the prosperity of manufactures. Every nation, with a view to those great objectives, ought to endeavor to posses within itself all the essentials of national supply."

Part I

MANUFACTURING AND NATIONAL ECONOMIC GROWTH

The argument that manufacturing industries play a *special* role in the growth process involves two related propositions: (i) that manufacturing activity contributes to overall growth in ways not reflected in conventional output measures; and (ii) that this *growth premium* is larger in the case of manufacturing relative to its output share than for other sectors of the economy.

In assessing these propositions, this section begins from the assumption that full appreciation of manufacturing's role requires an exploration of the interaction *among* manufacturing industries and *between* manufacturing and the economy at large. In the 1920s, British economist Allyn Young identified the network of such relationships—i.e., the interindustry division of labor that he termed *roundaboutness* in production—as a major source of returns to scale in the national economy:

> *[T]he mechanism of increasing returns is not to be discerned adequately by observing the effects of variations in the size of an individual firm or of a particular industry, for the progressive division and specialization of industries is an essential part of the process by which increasing returns are realised. What is required is that industrial operations be seen as an interrelated whole.*[5]

The effort to explain growth in these terms encounters serious obstacles that Young himself acknowledged. Some of these relate to the difficulty of calculating industry and firm-level effects that are novel and qualitative.[6] Other problems are theoretical. The principle of increasing returns challenges the prevalent assumption that the price

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[5]"Increasing Returns and Economic Progress," The Economic Journal (December 1928), 539. In articulating these ideas, Young (527) built upon "Alfred Marshall's fruitful distinction between the internal productive economies which a particular firm is able to secure as the growth of the market permits it to enlarge the scale of its operations and the economies external to the individual firm which show themselves only in changes of the organization of the industry as a whole"; and (529) "Adam Smith's famous theorem that the division of labour depends upon the extent of the market."

[6]*Op. cit.*, 528: "Out beyond [the individual firm], in that obscurer field from which it derives its external economies, changes of another order are occurring. New products are appearing, firms are assuming new tasks, and new industries are coming into being. In short, change in this external field is qualitative as well as quantitative."

mechanism impels free markets toward equilibrium. The possibility that markets may cultivate monopoly power or, indeed, that some sectors may generate especially high returns to the general economy over long periods, complicates both policymaking and economic research.[7] These difficulties notwithstanding, the idea that inputs to manufacturing activity generate increasing returns to the overall economy is the theoretical umbrella for much of the discussion in Part I.

MANUFACTURING AND THE NATIONAL ECONOMY—SELECTED GROWTH-RATE COMPARISONS

If manufacturing production generates increasing returns, even if these returns cannot be tracked or quantified separately, their compound effect should be visible in the overall growth rate. Three decades ago, British economist Nicholas Kaldor affirmed the existence of such an effect in what has been called as Kaldor's first law of economic growth:

> *The faster the rate of growth of the manufacturing sector, the faster will be the rate of growth of…[GDP], not simply in a definitional sense in that manufacturing output is a large component of total output, but for fundamental economic reasons connected with induced productivity growth inside and outside the manufacturing sector.*[8]

Kaldor argued that growth in manufacturing output—driven in less developed economies by increasing demand in the farm sector, and in advanced economies by rapid export growth—had doubly positive implications for GDP. It spurred productivity growth within manufacturing—e.g., by creating incentives for differentiation in the production process.[9]

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[7]On the research problem, see Paul Samuelson, "Bertil Ohlin: 1899-1979," Journal of International Economics, 11 (1981), 152. Samuelson observes that "the phenomenon of increasing returns negates the nice convexity properties that are so beloved by us lazy mathematical economists hell-bent for elegance of formulation. Instead, we are in a world of multiple local maxima, one in which things often get worse before they get better. A horrible combinatorial problem of description and computation faces us with all the unmanageable complexities of digital programming and much worse." Samuelson's observation is cited in John S. L. McCombie, "Kaldor's laws in retrospect," Journal of Post Keynesian Economics, V (Spring 1983), 427.

[8]This formulation of Kaldor's first *law* appears in A.P. Thirwall, "A plain man's guide to Kaldor's growth laws," Journal of Post Keynesian Economics, V (Spring 1983), 345. Kaldor's original thesis, published as Causes of the Slow Rate of Economic Growth of the United Kingdom (Cambridge University Press 1966), was based on an analysis of 12 developed countries over the period 1953-54 to 1963-64. Kaldor's laws have been the focus of much debate; the Spring 1983 edition of the Journal of Post Keynesian Economics is devoted entirely to this pursuit. A recent effort to validate these laws appears in H. Sonmez Atesoglu, "Manufacturing and economic growth in the United States," 25 Applied Economics (1993), 67-69.

[9]This explanation echoes Allyn Young's discussion of increasing returns. Young had been Kaldor's teacher at the London School of Economics. Kaldor's argument also relies heavily on the work of P.J. Verdoorn, "Fattorie che Regolano lo Sviluppo della Produttivita del Lavoro," L'Industria (1949). Based on a cross-sectional analysis of countries in the interwar period, Verdoorn posits a strong positive correlation between manufacturing output and productivity growth. See Thirwall, *op. cit.*, 346, 349.

And by drawing underemployed labor into manufacturing from other sectors, it induced productivity growth in those sectors as well.

Other economists including Colin Clark and Simon Kuznets have also attributed a strategic role to manufacturing, especially in the early stages of national economic development.[10] Kuznets in particular pointed to the fact that apart from poverty itself the most pervasive characteristic of low-income countries in the mid-1950s was a puzzling failure to industrialize. Significantly, in recent decades, several of the countries on Kuznets's list of low-income LDCs have experienced very rapid growth—e.g., South Korea, Thailand, India, and Egypt. Table 1 indicates that, except for Egypt, overall development has been accompanied by a spreading of what Kuznets termed the *industrial system*.

Table 1
Economic and Manufacturing Growth in Developing Countries
(Average Annual Growth Rates)

	1953-60	1960-69	1970-80	1980-90
South Korea				
GDP	**4.8**	**8.1**	**8.1**	**9.3**
Manufacturing	**13.6**	**15.5**	**15.5**	**11.8**
Mfg. Share of GDP	**10.4(1)**	**20.3**	**20.3**	**30.1**
Thailand				
GDP		**6.8**	**6.8**	**7.7**
Manufacturing		**10.1**	**10.1**	**9.2**
Mfg. Share of GDP		**18.8**	**18.8**	**23.2**
India				
GDP	**3.8**	**3.3**	**3.3**	**5.5**
Manufacturing	**5.9**	**4.1**	**4.1**	**7.4**
Mfg. Share of GDP	**12.2**	**15.5**	**15.5**	**18.5**
Egypt				
GDP		**9.6**	**9.6**	**5.0**
Manufacturing		**9.4**	**9.4**	**4.1**
Mfg. Share of GDP		**31.4**	**31.4**	**28.8**

(1) Manufacturing shares of GDP at end of periods.
Sources: World Bank Tables 1980 and 1993. All calculations based on inflation-adjusted values.

[10]Looking back over the experience of the developed economies of the day and out across nations then at different stages of development, Kuznets drew two conclusions that have since become widely accepted. The first was that modern economic development is characterized by long periods of very rapid output growth; the second, that these periods coincide in all cases with a structural shift in the composition of output away from agriculture and toward manufacturing. See his Six Lectures on Economic Growth (Glencoe, Ill.; The Free Press, 1959), 23-25, 43. Also Colin Clark, Conditions of Economic Progress.

In industrially developed countries, however, the role of manufacturing as an engine of growth seems less certain. Critics have shown that a key element of Kaldor's theory, the link between output and productivity growth in manufacturing, does not hold in advanced economies.[11] The complexity of the growth process in these settings may defy formulation in a single statistical correlation. Kaldor's formulation, for example, fails to account for the possibility that economic growth may be accelerated over considerable periods by the diffusion of advanced technology from the most advanced to relatively less advanced industrial countries.

Experience in several G-7 countries also contradicts Kaldor's theory. In recent decades, for example, the United States, Germany, the United Kingdom, and Canada have achieved respectable rates of overall growth, with manufacturing output increasing more slowly than GDP and manufacturing employment in a state of relative or absolute decline. (Table 2 and Table 3.)

If manufacturing activity has some special growth-inducing effect in developed economies, therefore, the effect must operate in ways not fully accounted for by growth in the manufacturing sector itself.

[11]Various criticisms of Kaldor's theory are summarized in John S.L. McCombie, "Kaldor's laws in retrospect," Journal of Post Keynesian Economics (Spring 1983), 414-28. For a discussion of problems with model specification in Kaldor's interpretation of Verdoorn's Law (i.e., linkage between output and productivity growth in manufacturing), see Thomas R. Michael, "International comparisons of productivity growth: Verdoorn's Law revisited," Journal of Post Keynesian Economics (Summer 1985), 474-92.

Table 2
Economic and Manufacturing Growth in Developed Countries
(Average Annual Growth Rates)

		1951-60	1961-70	1971-80	1981-90
United States					
	GDP	**3.3**	**3.8**	**2.7**	**2.6**
	Manufacturing	**2.8**	**4.1**	**2.8**	**2.4**
Canada					
	GDP	**4.6**	**5.0**	**4.6**	**2.9**
	Manufacturing	**4.2**	**5.8**	**3.5**	**2.2**
West Germany					
	GDP	**8.5**(1)	**4.4**	**2.7**	**2.2**
	Manufacturing	**11.3**(1)	**5.5**	**1.9**	**1.5**
Japan					
	GDP	**8.2**	**10.5**	**4.5**	**4.1**
	Manufacturing	**11.3**	**15.5**	**5.2**	**5.8**
United Kingdom					
	GDP	**2.5**	**2.9**	**1.9**	**2.7**
	Manufacturing	**3.4**	**1.9**	**-0.2**	**1.4**

(1) Growth rates calculated for 1952-60.

Sources: National Accounts, OECD; World Tables, World Bank; Survey of Current Business and The National Income and Product Accounts of the United States, U.S. Department of Commerce; Comparative Labor Statistics, Bureau of Labor Statistiics, U.S. Department of Labor.

Table 3
Manufacturing Shares in Developed Countries
(Percent of Total)

		1950	1960	1970	1980	1990
United States						
	Output	**21.5**	**20.5**	**21.1**	**19.2**	**18.9**
	Employment		**26.1**	**26.4**	**22.1**	**18.0**
Canada						
	Output	**19.0**	**18.4**	**19.8**	**17.9**	**16.7**
	Employment		**24.7**	**22.3**	**19.7**	**15.9**
West Germany						
	Output	**24.7**	**31.9**	**35.3**	**32.5**	**30.2**
	Employment		**34.4**	**39.5**	**34.0**	**31.6**
Japan						
	Output	**12.8**	**16.0**	**25.1**	**26.8**	**31.4**
	Employment		**21.7**	**27.4**	**25.0**	**24.3**
United Kingdom						
	Output	**29.2**	**31.7**	**28.8**	**23.4**	**20.6**
	Employment		**36.0**	**34.7**	**28.3**	**20.1**

Sources: Same as Table 2.

INPUT-OUTPUT RELATIONSHIPS AMONG MANUFACTURING AND NON-MANUFACTURING INDUSTRIES IN THE U.S. ECONOMY

Input-Output (I-O) analysis of inter- and intra-industry production flows and employment multipliers illuminates some of that *obscurer field* that Allyn Young associated with increasing returns at the sectoral level.[12] The analysis suggests that, compared with nonmanufacturing industries, manufacturing exercises the nation's productive capacities more extensively, eliciting a broader array of inputs and providing special opportunities for productivity growth. Moreover, by cultivating diversity in the nation's material and human resource base, manufacturing industries may help the economy to resist shocks and exploit emerging growth opportunities.

[12]Input-output analysis is a way of estimating the flow of goods and services among industries in response to changes in intermediate and final demand. I-O tables can also be used with supplemental data to estimate the effects of such changes on sector-by-sector employment and other factors. The present analysis uses 1977 and 1987 tables to compare the effects of changes in intermediate and final demand for manufactured *and* nonmanufactured outputs on inter-industry production flows and sectoral employment.

EFFECTS OF CHANGES IN FINAL DEMAND ON INTER-AND INTRA-INDUSTRY FLOWS OF GOODS AND SERVICES

For a given industry, the ratio of gross output to final demand (net of goods and services sold for intermediate uses) is an instructive, if imperfect, proxy for interindustry transfers of goods and services in the production process.[13] The ratio constitutes a kind of index of interindustry activity—a measure of what economists have called roundaboutness in production.

Table 4 compares the amount of gross output required to satisfy a given amount (i.e., one unit) of final demand for manufactured and nonmanufactured outputs (measured in constant 1982 dollars) for the years 1977 and 1987. The table shows that:

- Manufacturing had a much higher activity ratio than nonmanufacturing in 1977 (2.50 compared with 1.69) and 1987 (2.28 compared with 1.70). That is to say, a unit of final demand for manufactures supported more intermediate activity—more turn-over, more diversity and differentiation in the production process.

- Specifically, on the question of sectoral diversity, the table shows that manufacturing industries draw more heavily on nonmanufacturing industries than the latter do on the former. Gross nonmanufacturing output per unit of final demand for manufactures was 0.71 in 1977 and 0.59 in 1987. In contrast, gross manufacturing output per unit of final demand for nonmanufactures was only 0.27 in 1977, and 0.25 ten years later.

- Final demand for manufactures also drives a great deal of intermediate activity, and presumably a high degree of functional differentiation, within the manufacturing sector itself. Gross manufacturing output (i.e., the sum of outputs by manufacturing industries alone) per unit of final demand for manufactures was 1.78 in 1977 and 1.69 in 1987. The comparable ratios for nonmanufacturing were 1.43 and 1.45.

[13] An industry's *gross output* is the sum of its own value added and the cost of the materials and services it purchases from all other industries.

Table 4
Manufacturing *vs.* Nonmanufacturing
Gross Output Requirements Per Unit of Final Demand

	Output		
Source of Demand	Manufacturing	Nonmanufacturing	Total Economy[1]
		1977	
Manufacturing	**1.78**	**0.71**	**2.50**
Nonmanufacturing	**0.27**	**1.43**	**1.69**
		1987	
Manufacturing	**1.69**	**0.59**	**2.28**
Nonmanufacturing	**0.25**	**1.45**	**1.70**

(1) Totals may not sum because of rounding.

Source: U.S. Department of Commerce, Office of Business and Industrial Analysis. Aggregate results based on Bureau of Labor Statistics 1977 Input-Output tables.

EFFECTS OF CHANGES IN FINAL DEMAND ON THE CROSS-INDUSTRY DISTRIBUTION OF EMPLOYMENT

Table 5 compares the number of jobs required directly and indirectly to satisfy $1 million of final demand for manufactured and nonmanufactured outputs ($1982) for the years 1977 and 1987. The table indicates that the manufacturing sector draws more heavily on the nonmanufacturing sector than the latter does on the former:

- In 1987, 22 workers were needed on average to satisfy $1 million of final demand for manufactures (significantly fewer than in 1977). Of these, 14 were employed in manufacturing industries and 8 in non-manufacturing industries.

- By contrast, 32 workers were needed on average to satisfy $1 million of final demand for nonmanufacturing products in 1987 (only 1 less than in 1977). Of these, only two were from manufacturing industries; the other 30 were employed outside the manufacturing sector.

It should be noted, however, that between 1977 and 1987, the manufacturing sector's overall employment requirement declined substantially, with most of the reduction focused in the manufacturing sector itself. The sector's main contribution to the nation's human resource base during this period, therefore, may have been less in the quantity than in the variety of employment it supported.

Together, the analyses of interindustry output and employment linkages reveal an important, and not easily quantified, aspect of manufacturing's ability to generate increasing returns in advanced economies—i.e., the tendency to support more variety in production than nonmanufacturing industries do. A second aspect of manufacturing's special growth-inducing role in advanced economies pertains to the development and diffusion of technology.

Table 5
Manufacturing *vs.* Nonmanufacturing
Employment Requirements Per Million Dollars of Final Demand

	Jobs		
Source of Demand	Manufacturing	Nonmanufacturing	Total Economy[(1)]
		1977	
Manufacturing	**18.0**	**9.5**	**27.5**
Nonmanufacturing	**2.5**	**30.8**	**33.3**
		1987	
Manufacturing	**13.6**	**8.4**	**22.0**
Nonmanufacturing	**2.0**	**30.5**	**32.5**

(1) Totals may not sum because of rounding.

Source: Same as Table 4.

THE ROLE OF MANUFACTURING INDUSTRIES IN TECHNOLOGY DEVELOPMENT AND DIFFUSION

Manufacturing industries are especially adept at technology development and diffusion. The evidence suggests: (i) that manufacturing industries are important developers and disseminators of technology; (ii) that this phenomenon is neither accidental nor transitory, but related to the nature of manufacturing itself; and (iii) that the technology generated by manufacturing industries is a major determinant of national economic growth.

MANUFACTURING INDUSTRIES ARE A MAJOR SOURCE OF TECHNICAL KNOWLEDGE

In 1993, the most recent year for which aggregate data are available, private industries (including nonmanufacturing industries) performed 70 percent of all U.S. R&D—$112.3 billion out of a total $160.8 billion, about average for the 1970-1993 period.[14]

Some R&D performed by industry is paid for by government, but industry funds the lion's share itself. In 1991, the most recent year for which sector-specific data are available, private companies financed $76.9 billion of the R&D they performed—more than half of all U.S. R&D spending for the year. Manufacturing firms supplied about 91 percent ($70.1 billion) of this total, also about average for the period since 1970. Of the nonmanufacturing share of industry R&D spending in 1991, almost half ($3.2 billion) was accounted for by computer-related services (e.g., programming, data processing, engineering).[15]

WHY MANUFACTURING INDUSTRIES CONSISTENTLY ACCOUNT FOR MOST PRIVATELY-FUNDED R&D

One reason why manufacturing firms account for such a large share of industry-financed R&D seems to be that the returns to R&D investment, in terms of productivity growth and profitability, are higher in manufacturing than other industries. Reasons for this probably include opportunities peculiar to manufacturing industries for applying technology to specialized functions and for achieving economies of scale at the plant and firm level. They may also include the fact that accretions of technical knowledge are readily and reliably embodied in manufactured goods and, more fundamentally, that since R&D is mainly about material qualities, its applicability to making material things is inherent in the R&D enterprise itself.

Evidence on industry-level returns to R&D emerges mainly from a line of econometric research, dating from the mid-1970s, on the relation between R&D spending and total factor productivity growth at the industry and firm level. Initially, this work focused

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[14]National Science Board, Science & Engineering Indicators—1993 (Washington, D.C.; U.S. Government Printing Office, 1993), Appendix A, Table 4-4. Data are preliminary for 1992 and estimated for 1993. Improved measurement practices are expected to result in significant upward revisions in the estimates of industry and U.S. R&D spending for 1993. Total R&D spending by industry includes industry-funded R&D performed by universities, and non-profit institutions.

[15]*Ibid*., Tables 4-30 and 4-34.

almost entirely on manufacturing industries, with little effort to explore differences in the rate of return to R&D across sectors, or to consider sectors that perform relatively little R&D.[16]

However, a recent study by the Bureau of Labor Statistics (BLS) may advance understanding in both of these areas. The authors estimate accumulated research stocks for manufacturing and *non*manufacturing industries and compare returns to R&D in both sectors of the economy. They conclude that "the direct influence of R&D on productivity growth is greatest in manufacturing ....[while] the direct research effect is almost nil in nonmanufacturing."[17]

Presumably, high rates of productivity growth are generally, if not always, convertible to increased profitability, and this prospect drives R&D investment. Company officials responding to an NSF survey, for example, attribute declines in R&D spending in recent years to diminished sales and profit expectations, a concurrent decline in federal R&D contracting, and unspecified business conditions.[18] The far-reaching importance of incentives to R&D inherent in manufacturing is revealed in the efforts of twentieth century economists to identify the sources of modern economic growth.

TECHNICAL KNOWLEDGE, R&D, AND THEORIES OF MODERN ECONOMIC GROWTH

Economists now widely recognize the central importance of technological change in the process of economic growth. Though the roots of this idea stretch back to classical

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[16]This research is summarized in BLS, The Impact of Research and Development on Productivity Growth, Bulletin 2331 (U.S. Department of Labor; Washington, D.C., 1989), 13. A notable exception is Nestor E. Terleckyj, Effects of R&D on the Productivity Growth of Industries: An Exploratory Study (Washington, D.C.; National Planning Association, 1974). Terleckyj estimated that the *rate of productivity return* on R&D spending was 30 percent in manufacturing industries (p. 37). "No corresponding correlation was found for the nonmanufacturing industries." Terleckyj's study (which is also discussed below) uses productivity data for 20 manufacturing and 13 nonmanufacturing industries compiled by John W. Kendrick.

[17]*Op. cit.*, 21. This comparison is subject to serious and well-known measurement problems. One of these concerns the quality of the R&D data itself. The authors of the BLS report observe that "there is at present no fully reliable way to separate research stocks into their manufacturing and nonmanufacturing components"(16). A second problem relates to the difficulty of defining output (e.g., integrating factors of quantity and quality) and calculating productivity in broad areas of the nonmanufacturing sector. A more recent and refined estimate was produced by BEA in 1994 and included in the Budget of the United States Government - Analytical Perspectives, Fiscal Year 1995.

[18]National Science Foundation, National Patterns of R&D Resources: 1992, J.E. Jankowski, Jr., NSF 92-330 (Washington, D.C., 1992), 10, cites "Planned R&D Expenditures of Major U.S. Firms: 1991-92," a survey performed under contract to NSF by Aspen Systems Corporation.

economics, the idea's most elegant formulation in the twentieth century appears in the work of Joseph Schumpeter.

Schumpeter characterized modern growth as a process of dynamic change in which technological development drives rapid increases in productivity and creates whole new industries while making other industries obsolete. "The fundamental impulse that sets and keeps the capitalist engine in motion," he argued:

> *comes from the new consumers' goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates....[Capitalism is a] process of industrial mutation...that incessantly revolutionizes the economic structure* ***from within****, incessantly destroying the old one, incessantly creating a new one. This process of Creative Destruction is the essential fact about capitalism (emphasis original).*[19]

Since the mid-1950s, economists have tried to quantify technology's effect on economic growth. In the earliest and most celebrated of these efforts, Robert Solow found that of the total increase in U.S. output per man-hour between 1909-1949, seven-eighths could be attributed to apparent technical change and only one-eighth to increased capital.[20]

In Solow's original formulation, however, technical change was a residual, an unarticulated category of influences accounting for that portion of growth in output per man-hour that could not be attributed to increases in capital. The approach offered little insight into the importance of conventional R&D—or indeed the relative importance of technology development and technology dissemination—in this set of influences.

In contrast, later studies which *do* focus on R&D spending as a discrete variable indicate, almost without exception, that "returns to R&D are extremely high and that R&D is the strongest and most consistent influence on observed multifactor productivity growth."[21] On the basis of 13 such studies published between 1973 and 1986, BLS has estimated that "the direct impact of research is 30 percent"—that is to say, annual changes in the estimated *stock* of R&D (i.e., the sum of annual expenditures adjusted for estimated inflation and depreciation) explain 30 percent of the annual change in total factor productivity growth in the investing firms and industries.[22]

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[19]*Op. cit*., 83. Kuznets, *op. cit*., 14-15, offers an almost identical explanation of the growth process.

[20]"Technical Change and the Aggregate Production Function," The Review of Economics and Statistics (August 1957), 316.

[21]BLS, *op. cit*., 1. The authors go on to say that "[e]vidence from specific R&D projects provides further support for the notion that research has a substantial impact on output growth."

[22]*Ibid*., 13.

Recent research at the Census Bureau's Center for Economic Studies (CES) corroborates the BLS estimate. Using plant-level performance data from CES's Longitudinal Research Database and firm-level R&D investment data from the Bureau's Annual Survey of Industrial R&D, Frank Lichtenberg and Donald Siegal estimate a 35-percent rate of return to company-funded R&D for a representative sample of over 2000 companies.[23]

Even more important, perhaps, several of the studies identified by BLS and Lichtenberg and Siegal suggest that the *indirect* effects of industry R&D (i.e., productivity growth in downstream industries that buy new technology embedded in improved materials and equipment) may be considerably larger than the direct effects (i.e., the productivity returns to firms actually doing the R&D). In one of the first efforts to gauge these indirect effects, Nestor Terleckyj (1974) estimated the indirect productivity return per unit of R&D investment in a group of 20 manufacturing industries at 80 percent. More recently, using line of business data from 443 large U.S. corporations, F.M. Scherer has estimated the downstream return on product R&D at between 70 percent and 104 percent.[24] These results are consistent with a more recent and influential finding by Bradford DeLong and Lawrence Summers that investment in producers machinery and equipment is a major source of overall economic growth.[25]

Efforts to calculate productivity returns to R&D are complicated by a variety of factors, including fragmentary data, methodological difficulties, and uncertainty about operational connections among the variables. In addition, it appears that the returns to R&D are not uniform, but vary substantially depending on the sponsorship and character of the work. For example, analysis by Terleckyj and others since the early 1970s indicates that, in contrast to R&D financed by industry itself, federally-financed R&D has little or no direct effect on productivity growth in the performing industry. This finding is at least partly explained by the fact that so much federal spending goes to basic science which results in

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[23]"Impact of R&D Investment on Productivity—New Evidence Using Linked R&D-LRD Data," Economic Inquiry, XXIX (April 1991). The authors observe that their estimate is "quite similar to the mean (of all previous studies) estimate of 29.5 percent for the same parameter" (214). Table IV in their article is a summary of these studies. Based on the Census Bureau's quinquennial Census of Manufactures and Annual Survey of Manufactures, the Longitudinal Research Database (LRD) includes data on inputs and outputs of 300,000 to 400,000 individual manufacturing plants from 1963 to the early 1990s. Lichtenberg and Siegal consider it "the most comprehensive and accurate longitudinal microdata yet available for productivity analysis"(204).

[24]Terleckyj's study is cited above in *fn 16*. Scherer's conclusion appears in "Inter-Industry Technology Flows and Productivity Growth," The Review of Economics and Statistics (November 1982), 633. BLS, *op. cit*., 2, observes that indirect returns "may well account for the larger portion of the total impact of research and development."

[25]"Equipment Investment and Economic Growth," Quarterly Journal of Economics (May 1991), 445-502. Solow, in his own seminal article (1957), observed that despite the predominant influence of technical change in explaining economic growth, increased capital per man-hour was also important because "much, perhaps nearly all, innovation must be embodied in new plant and equipment to be realized at all."

unmeasured indirect benefits and defense projects that generate few direct commercial spin-offs.[26]

The *composition* of R&D also seems to influence measured productivity performance. There is considerable evidence, for example, that process R&D has a more powerful direct effect than product R&D on productivity growth in the R&D-performing industry; while the principal effects of product R&D are passed on to downstream industries and consumers. The evidence also suggests that productivity returns to basic R&D are much higher than returns to applied R&D.[27]

In summary, therefore, this study concludes that manufacturing industries *do* have special growth-inducing properties. More than other industries, they allow specialization in the production process and they develop technology and disseminate it throughout the economy.[28]

It is equally clear, however, that there have been major changes in the U.S. manufacturing sector—changes that are part of the structure and substance of the growth process itself, and that have implications not only for the rate of growth, but for how the benefits of growth are allocated to American workers. Part II treats these changes and their implications.

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[26]See Terleckyj, 21; and BLS, 10-11. Lichtenberg and Siegel support this finding (225). However, BLS (11) cites research in the mid-1980s by Edwin Mansfield and Lichtenberg showing that federal R&D spending can be a major stimulant to private R&D.

[27]See BLS, 11-12 on product and process R&D, and Lichtenberg and Siegal, 215, 225, on basic versus applied R&D. Research also suggests that the quality of opportunity for R&D and, therefore, marginal returns to R&D investment may vary over time. On the last point, see BLS, 14, and Tables 14 and 15.

[28]However, this finding does not indicate that manufacturing industries *alone* possess these qualities; indeed, nonmanufacturing sectors account for an increasing if still relatively small share of private R&D.

Part II

THE NEW FACE OF AMERICAN MANUFACTURING

The new face of American manufacturing is a product of profound and continuing change in the composition of manufacturing output and employment and in the structure of manufacturing firms themselves.

The next three sections describe and explain these developments. Taken together, they lend support to the Schumpeterian view that growth is a process of *creative destruction* in which major technological advances create new venues for enterprise and make other venues obsolete. They also illuminate the principal agents of this process—new (or newly dynamic) firms that structure themselves to extract economies of scale and scope inherent in the new technologies.

CHANGES IN THE COMPOSITION OF MANUFACTURING OUTPUT

Examination of the composition of industrial output over the 1981-90 and 1960-90 periods reveals a pattern of rapid and concentrated change.[29] As a group, the 30 fastest-growing industries grew much faster than overall manufacturing, 7.8 percent per year on average between 1981 and 1990, compared with 2.8 percent for the sector at large. The 30 slowest-growing industries increased output more slowly than the sector as a whole, 1.2 percent per year on average. Industries in the top-30 group accounted for 30 percent of total manufacturing output in 1990, compared with only 17.5 percent in 1960. The slow-growers' output share declined over the 30-year period from 26 percent to 17

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[29]The BLS industry classification, which is followed throughout this section, divides the entire U.S. economy among 228 industries, of which 115 are manufacturing. See Outlook 1990-2005, Appendix B-1 for definitions of these industries.

The analysis focuses on real output ($1982) for 1981-90 and for 1960 to 1990. It uses time-series data (1960-90) on gross output by industry and the BLS input-output tables for 1977 and 1987. Gross output data include the value of purchased materials and services, in addition to value-added in a particular industry. Thus, gross output implies double counting. However, it is the only measure available in constant dollars at the level of industry detail needed for trend analysis.

Comparable output data are not available after 1990. In some instances, substantial changes have occurred or are expected to occur for certain industries. For example, recent reductions in defense spending will adversely affect several industries. For further explanations of trends in industry behavior, especially since 1990, see the 1993 U.S. Industrial Outlook and "Industrial Output and Employment Effects of Planned Cuts in Defense Spending, 1991-1996", by David K. Henry, U.S. Department of Commerce, June 1992.

percent. (Lists of fastest and slowest growing industries by output are included in the Appendix, Table A 1 and Table A 2.)

Analysis of input-output relationships indicates that, between 1977 and 1987, investment demand was the most powerful source of output growth for the top gainers. (Table 6.) Gainers also benefited from government purchases and export demand. The effect of imports was ambiguous. Between 1977 and 1987, almost all of the fast-growing industries (and a few slow-growers) expanded exports. Also, both the gainers and losers experienced increased import penetration. In conditions of increased exposure to foreign competition, however, many gainers seemed to thrive while losers often languished.

Table 6
Thirty Fastest and Thirty Slowest Growing Industries by Output
Sources of Output Growth, 1977-1987(1)

	Thirty Fastest Growing Industries	Thirty Slowest Growing Industries	Total Manufacturing
Growth Rate	7.7	**-1.4**	1.7
Growth from:			
Interindustry Demand	1.1	**-2.3**	-0.6
Final Demand	6.6	**0.9**	2.3
Growth of Output by Type of Final Demand:			
Household Demand	1.4	**1.2**	1.5
Investment Demand	3.4	**0.4**	1.0
Government Demand	2.4	**0.4**	0.7
Export Demand	2.3	**0.5**	0.8
Import Demand	-2.8	**-1.6**	-1.8

(1) Rankings reflect industry performance for 1981-90. Input-output analysis of the determinants of output covers 1977-87 in those industries.
Sources: Office of Business Analysis and Bureau of Labor Statistics (based on BEA data).

I-O analysis also provides at least a partial perspective on the way that technology affects the composition of output. Between 1977 and 1987, almost all of the fast-growing industries were favored by shifting patterns of *interindustry demand*—i.e., by changes in production technology. Increased output in the Plastics industry, for example, seems to have been caused mainly by the substitution of plastics for steel by steel-using industries, particularly automobiles. For some fast growing industries, however (e.g., Miscellaneous electronic components), *and virtually all slow-growing industries*, output effects of technological change were negative. That is, technology shifted demand away from their products. (Detailed I-O tables are included in the Appendix, Table A 3 and Table A 4.)

The fact that many fast-growers are new industries or established industries producing new products also reflects technology's influence on the structure of output. Between 1960 and 1990, for example, the Computer industry moved from 114th to second (out of 115) in the output rankings ($1982); Miscellaneous plastics products moved from 62nd to sixth; Drugs from 60th to 20th. (Table 7.) BEA industry classifications for 9 of the 30 fastest growing industries in the 1981-90 period, begin with the word *miscellaneous* and/or end with the designation of *nec* (not elsewhere classified), indicating products that were not important as late as 1980. (Table A 1.)

Table 7
Thirty Largest Manufacturing Industries by Gross Output
(Billions of 1982 Dollars)

	1990		1960	
Industry	Output	Rank	Output	Rank
Petroleum refining	**232**	**1**	**112**	**1**
Computer equipment	**171**	**2**	**<1**	**114**
Motor vehicles and car bodies	**115**	**3**	**34**	**5**
Industrial chemicals	**78**	**4**	**31**	**6**
Meat products	**73**	**5**	**37**	**4**
Misc. plastics products, n.e.c.	**59**	**6**	**6**	**62**
Blast furnaces and basic steel products	**58**	**7**	**66**	**2**
Motor vehicle parts and accessories	**58**	**8**	**55**	**3**
Grain mill products, fats and oils	**54**	**9**	**24**	**9**
Commercial printing and business forms	**49**	**10**	**15**	**16**
Pulp, paper and paperboard mills	**44**	**11**	**18**	**12**
Apparel	**43**	**12**	**27**	**8**
Dairy products	**42**	**13**	**28**	**7**
Plastics materials and synthetics	**40**	**14**	**9**	**37**
Aircraft	**40**	**15**	**17**	**13**
Weaving, finishing, yarn and thread mills	**37**	**16**	**24**	**10**
Fabricated structural metal products	**37**	**17**	**19**	**11**
Misc. electronic components	**35**	**18**	**5**	**71**
Paperboard containers and boxes	**34**	**19**	**12**	**25**
Drugs	**32**	**20**	**6**	**60**
Soap, cleaners and toilet goods	**31**	**21**	**9**	**34**
Preserved fruits and vegetables	**31**	**22**	**15**	**15**
Nonferrous rolling and drawing	**30**	**23**	**16**	**14**
Measuring and controlling devices; watches	**29**	**24**	**8**	**42**
Search and navigation equipment	**28**	**25**	**6**	**61**
Misc. food and kindred products	**25**	**26**	**14**	**22**
Soft drinks and flavorings	**25**	**27**	**7**	**50**
Cement, concrete, gypsum and plaster products	**25**	**28**	**15**	**21**
Alcoholic beverages	**25**	**29**	**11**	**31**
General industrial machinery	**24**	**30**	**13**	**23**
Top Thirty Manufacturing Industries	**1,604**		**657**	
Total Manufacturing Output	**2,585**		**1,117**	
Top Thirty Share of Total (Percent)	**62**		**59**	

Note: Detail may not sum to total because of rounding.

Sources: Bureau of Labor Statistics, U.S. Department of Labor and Bureau of Economic Analysis, U.S. Department of Commerce.

CHANGES IN THE COMPOSITION OF MANUFACTURING EMPLOYMENT

Between 1960 and 1992, the number of jobs in the U.S. economy nearly doubled—from 68.5 million to 121 million. In contrast, the number of jobs in U.S. manufacturing industries increased gradually from 17.3 million in 1960 to a peak of 21.4 million in 1979, and fell back to 18.4 million in 1992. Over the entire period, U.S. manufacturing industries' employment share fell from roughly 25 percent to 15 percent, with half the decline concentrated in the years since 1980.[30]

Within this pattern of overall decline, job-gaining industries constitute a fairly compact group; job losers a more diffuse one. The 30 fastest job gainers during 1981-90 accounted for 92 percent of all net gains (1.1 million net new jobs) and, by 1990, about a third of all manufacturing employment. In all, 45 manufacturing industries were net job gainers over the period. The remaining 70 manufacturing industries were net job losers.[31] The latter group employed 2.3 million fewer people in 1990 than in 1981. (Lists of fastest and slowest growing industries by employment are included in the Appendix, Table A 5 and Table A 6.)

In fact, high levels of job creation and destruction are a fact of life in all manufacturing industries. Newly published research at the Census Bureau's Center for Economic Studies shows that between 1973 and 1988, annual rates of gross job creation in the twenty 2-digit

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[30]Analysis in this section focuses mainly on the most recent business cycle, 1981-90. The number of U.S. manufacturing jobs continued to decline gradually during 1991-93. Near the end of that period, however, as the economic recovery gained momentum, the number of manufacturing jobs began to increase.

Employment in U.S. manufacturing industries may be declining more slowly than manufacturing employment in other industrial countries. See William J. Baumol, Sue Anne Batey and Edward N. Wolff, Productivity and American Leadership: The Long View (Cambridge, MA; MIT Press, 1989), 106; and OECD, Labor Force Statistics, 1970-1990 (Paris, 1992), 38-39. In the past two decades, there has been an upward trend in the U.S. share of industrial employment among the 24 OECD countries.

[31]The 30 industries that shed jobs most rapidly account for accounted for about 70 percent of all losses in the 70 industries that lost jobs during 1981-90. Annual loss rates were especially high in industry groups that account for large numbers of workers—e.g., Industrial machinery; Primary metals; and Transportation equipment.

A loss of jobs does not necessarily mean that an industry itself is in decline. In fact, output increased in 11 of the 30 fastest job-losing industries in the 1981-90 period. In the Electrical equipment and supplies industry, for example, employment declined at a 2.2- percent rate, but output increased at a 4.9-percent rate over the period.

In addition, the performance of individual establishments varies widely in all industries. Thus, even in industries that are net job losers, individual establishments may be net job creators. On this point, see Steven J. Davis, John C. Haltiwanger, and Scott Schuh, Gross Jobs Flow in U.S. Manufacturing, Bureau of the Census (Draft: March 1994).

manufacturing industries ranged from 6.2 to 12.4 percent. Over the same period, annual rates of gross job destruction in these industries ranged from 6.8 to 14.4 percent.[32]

The decline in manufacturing employment during the 1980s is not a consequence of deindustrialization. There was no parallel decline in the manufacturing share of total output over the period. Rather, it reflects the sector's faster than average productivity growth (2.4 percent per year compared with 1.6 percent for the private economy at large).

Nonetheless, the trends in both the number and quality of manufacturing jobs have profound implications for the manner in which the benefits of manufacturing production are conveyed to Americans. In the past, U.S. manufacturing industries have been beacons of economic opportunity, especially for immigrant populations from Europe and rural America. The ability of these industries to support comparatively high wages for semi-skilled workers has been part of the economic foundation of a growing American middle class. In recent years, however, U.S. manufacturing industries have become less effective instruments of income distribution and social mobility.

One reason for this has already been noted. The number of U.S. manufacturing jobs is declining; in a direct sense, manufacturing production generates fewer economic opportunities for American workers.

A second reason is that, as the number of manufacturing jobs has declined in relation to total U.S. employment, the number of production jobs—i.e., *blue collar* jobs, mainly in the lesser skilled employment categories—has declined as a share of manufacturing employment. Between 1960 and 1990, the number of manufacturing jobs of all kinds grew at a comparatively modest average rate of 0.4 percent; while employment growth in the blue collar job categories was barely perceptible (0.1 percent per year).

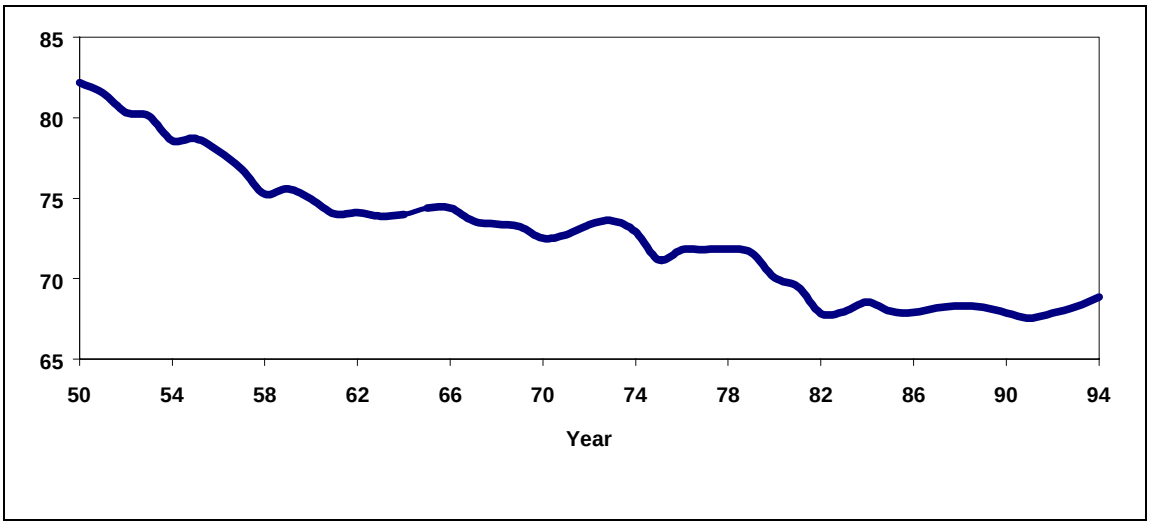
Much of the shift in manufacturing employment from production to other job categories occurred before 1982. (Figure 1.) Since then, on average, blue-collar categories have accounted for about 68 percent of all manufacturing jobs. Since 1991, indeed, the blue collar share has recovered from just over 67 percent to about 69 percent. (This development may reflect general changes in U.S. corporate structure that are discussed in the next section.)

Third, even if the number of manufacturing jobs was not declining, there might still be a question about whether most manufacturing jobs are as good as they used to be. Real average weekly earnings ($1982) for production workers in the manufacturing sector

[32]Davis, Haltiwanger, and Schuh, especially Table 3.1, "Job Flows by Two-Digit Industry, 1973 to 1988." For the manufacturing sector as a whole over the period, annual job creation averaged 9.1 percent; annual job destruction, 10.3 percent. According to the authors, these changes required at least 12 percent, and at most 19 percent, of all workers in manufacturing to change jobs or job status each year.

peaked at $368 in 1978, then declined gradually—except for a temporary rebound in the mid-1980s—until in 1990, they stood at $332.[33]

Figure 1
Production Workers
(Percent of Total Manufacturing)



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

[33]These earnings were higher than the earnings of workers in the service sector and in the private sector as a whole for the entire 1960-90 period. Beginning in the 1980s, however, real weekly earnings in the service sector have been rising. According to a recent study by Max Dupuy and Mark K. Schweitzer, between 1979 and 1992, the difference in the median salaries of workers in the service sector and the manufacturing and construction sector narrowed from $82/week to $19/week ($1992); "Are Service-Sector Jobs Inferior?" Economic Commentary, published by the Federal Reserve Bank of Cleveland, (February 1, 1994). Analysis based on average earnings alone does not show conclusively whether jobs being created or lost in manufacturing industries are good jobs—i.e., jobs that provide high wages *and* benefits for moderately skilled workers. A complete answer to the jobs quality question requires further analysis of the historical data relating to the structure of employment in specific industries.

TRADE PERFORMANCE AND JOBS

As a group, the 30 industries that had the highest employment growth during 1981-90 exported a somewhat smaller proportion of their output than the sector at large, but experienced far less import penetration in domestic markets. Like the gainers, job losers tended to be indifferent exporters. Unlike many of the gainers, however, the job losers faced substantial import penetration in their home markets. (Table 8.)

Table 8
Thirty Fastest and Thirty Slowest Growing Manufacturing Industries by Employment—Trade Performance, 1987

	Export to Output Ratio	Import Penetration Ratio
Thirty Fastest Growing Industries	**7.2**	**7.1**
Thirty Slowest Growing Industries	**8.0**	**19.0**
Total Manufacturing	**9.5**	**14.8**

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

TECHNOLOGY, PRODUCTIVITY, AND JOBS

The role of R&D investment and productivity growth in both job-gaining and job-losing industries is ambiguous. High-tech industries are found among the job losers as well as the gainers; and rapid productivity growth, though coincident with slow or negative employment growth in some industries, is also found in many of the top job gainers.[34] (Table 9.)

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[34]Of the top 30 job gainers, 8 qualify as *high tech* industries according to the *DOC-3* definition used by the Department of Commerce (i.e., industries or firms in which the ratio of total direct and indirect R&D investment to total sales generally exceeds 5 percent). Seven high tech industries also appear on the list of rapid job-losers. During the 1981-90 period, the high-tech job losers shed employment at a slower rate (3.0 percent) than the job-losing group as a whole (3.7 percent). Among the 115 manufacturing industries, 23 meet the DOC-3 high tech criterion. Between 1981 and 1990, these industries taken together accounted for little *net* new employment; jobs added by the gainers roughly equaled jobs lost by the losers. Over the same period, however, output gains by the high tech industries as a group averaged 6.4 percent per year.

With a few exceptions, R&D investment data are available only at the 2-digit SIC level. For the present analysis, therefore, industries in each general category are assumed to have uniform R&D intensities.

A recently published analysis of plant-level data supports the conclusion that high productivity growth may be coincident with *either* the downsizing *or* expansion of employment. See Martin Neil Baily, Eric J. Bartelsman and John Haltiwanger, "Downsizing and Productivity Growth: Myth or Reality?", Discussion Paper 94-4, Center for Economic Studies, U.S. Census

Table 9
Thirty Fastest and Thirty Slowest Growing Manufacturing Industries by Employment—Productivity Growth 1981-90

	Average Annual Employment Growth	Average Annual Productivity Growth
Thirty Fastest Growing Industries	**2.2**	**3.8**
Thirty Slowest Growing Industries	**-3.7**	**2.6**
Total Manufacturing	**-0.6**	**3.2**

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

Table 10 presents an input-output analysis of determinants of employment growth and decline for the thirty top gainers and losers for the 1977-87 period. The analysis indicates that increasing final demand was the most powerful positive influence on employment at the industry level among the gainers. Productivity increases coincided with significant negative employment effects for most indusries in the gainers group, but in 7 individual cases declining productivity coincided with a positive employment effect during 1977-87. (Detailed I-O Tables are included in the Appendix, Table A 7 and Table A 8.)

Importantly, however, for most of the top 30 job-gaining industries, productivity growth and employment growth were not inconsistent. Reductions in employment requirements resulting from labor productivity gains were more than offset by increases in final demand—possibly related to the pass-through of lower costs.[35]

Bureau (1994). The authors find that among *conventional downsizers*—i.e., plants that gained productivity and reduced employment between 1977 and 1987—employment fell at an annual rate of nearly 3.8 percent. But these job loses were almost completely offset by employment gains at plants that increased *both* productivity and employment over the period.

[35]In the computer industry, for example, productivity growth in the 1977-87 period might almost have eliminated labor from the production process had it not been for the powerful countervailing influence of falling prices and rapidly growing final demand—especially investment demand. In fact, the combination of these forces generated new jobs in the industry at an annual rate of 5.7 percent. At least two other high-tech jobs-gaining industries appear to conform to this pattern of high productivity growth, increasing final demand (especially in the form of business investment), and falling prices—Semiconductors and related devices; and Search and navigation equipment.

Table 10
Thirty Fastest and Thirty Slowest Growing Industries by Employment
Sources of Employment Growth, 1977-1987[(1)]

	Thirty Fastest Growing Industries	Thirty Slowest Growing Industries	Total Manufacturing
Growth Rate	2.5	**-3.3**	-0.3
Growth from:			
Interindustry Demand	-0.8	**-4.2**	-3.0
Final Demand	3.3	**0.9**	2.7
Growth of Output by Type of Final Demand:			
Household Demand	1.7	**2.4**	1.6
Investment Demand	1.0	**0.4**	1.4
Government Demand	1.2	**0.4**	0.9
Export Demand	0.5	**0.4**	1.0
Import Demand	-1.1	**-2.8**	-2.2

(1) Rankings reflect industry performance for 1981-90. Input-output analysis of the determinants of output covers 1977-87 in those industries.
Sources: Office of Business Analysis and Bureau of Labor Statistics (based on BEA data).

In the gainers group, employment effects of rapid productivity growth were also offset in many cases by changes in the structure of intermediate demand. In effect, despite rapid declines in their unit labor requirements, many industries in the gainers group generated new employment by becoming more important suppliers *to other industries*. Salient examples include the aircraft and missile parts, miscellaneous publishing, computer equipment, semiconductor, and miscellaneous plastics industries.

In recent years, the effect of technological change on employment has become a subject of increasing political and academic concern. In the broadest sense (as discussed in Part I, above), the connection between technology and jobs seems unequivocal: advances in technology have been the main drivers of modern economic growth and job creation. In the more bounded universe of I-O analysis, however, the evidence is mixed. Though technology—through its effect on productivity growth and the structure of interindustry demand—seems to raise employment levels in the job-gaining industries, its influence in job-losing industries appears to be negative. In the absence of technological progress, however, job loss would have been greater.

CHANGES IN CORPORATE STRUCTURE

From the late nineteenth century until the 1980s, very large, hierarchically organized, capital-intense companies seemed to dominate the manufacturing landscape exploiting advances in mechanical technology (e.g., steam power, direct reduction of metals, rail transportation, the telegraph and telephone) that favored mass production, process standardization, and centralized, layered management.[36] In the past decade, however, two forces—the globalization of production capability and technological change—have combined to dictate a new model of the competitive organization.

Globalization. New competitors have established their presence in world markets, from the industrialized nations of Europe to the first and second waves of Asian Tigers. (Table 11) In 1972, 275 of the world's 500 largest industrial corporations were U.S. companies; 119 were Japanese or *other* non-European companies. In 1992, only 161 were American; 237 were Japanese or other.

Table 11
500 Largest Industrial Corporations in the World by Country

Country	1972	1980	1990	1991	1992
United States	**275**	**217**	**164**	**157**	**161**
Japan	**60**	**66**	**111**	**119**	**128**
Britain	**49**	**54**	**43**	**43**	**40**
Germany	**32**	**38**	**30**	**33**	**32**
France	**25**	**29**	**30**	**32**	**30**
Other	**59**	**96**	**122**	**116**	**109**

Note: 500 largest corporations in terms of value of sales in U.S. dollars.
Source: Fortune Magazine (various issues).

This dispersion of economic power has had a winnowing effect on corporate structure and behavior. Operating strategies aimed at covering the board—i.e., competing in a broad product line in a growing list of major geographic markets—have given way to more focused approaches. Increasingly, corporate strategy seeks to identify those market segments or stages in the production process in which the firm has a unique and sustainable advantage.

Technological Innovation. The narrowing trend has been reinforced by advances in product and process technology. Rapidly expanding technological possibilities have made it increasingly difficult—in terms of R&D expenditures, equipment investment, and

[36]Chandler, op. *cit*., provides an exhaustive exploration of the relation between technology, corporate structure, and economic growth in the 1880-1950 period.

management time and attention—for firms to stay on the cutting edge of a wide range of activities. Firms must now concentrate their efforts on new products, new extensions of the market, new options for customization or for adding follow-on service.

Technology has influenced corporate structure in other ways, as well. *Informated* production (e.g., computer-aided design and manufacture, intelligent or flexible manufacturing) now allows a given plant to mimic the configuration of other plants dedicated to the production of other goods. In theory, at least, these capabilities reduce the scale needed to reach minimum average cost while expanding the range of products an informated firm can offer. The result, in manufacturing industries, should be a down-sizing of business units.[37]

In addition, the widespread application of sophisticated information generating and handling networks has made it possible for every aspect of a firm's operations to be transparent to its management. As a consequence, costly and cumbersome management pyramids built to process, verify, and distribute information are being dismantled.

Economic theory suggests that the boundary of the firm ought to lie at the point at which it is easier and cheaper to gather and process information through direct organizational channels (i.e., vertically) rather than through market signals (i.e., horizontally).[38] Otherwise, assemblages of market-based competitors could organize activities more effectively than any one firm. A century ago, the boundaries of manufacturing firms expanded and management hierarchies grew for precisely this reason. Today, however, advances in information technology have induced an opposite effect. Firms are shrinking; hierarchies are collapsing.

The restructuring process is still in its early stages. Systematic evidence of the diffusion of new technology, down-sizing, and the flattening of corporate hierarchies is limited, but suggestive.

DIFFUSION OF INFORMATION TECHNOLOGY SINCE 1975

Table 12 shows that the trend toward greater investment in information technology has been pervasive—not merely in the manufacturing sector, but in the economy at large. In

[37]Conversely, in non-manufacturing industries (e.g., wholesale and retail trade, financial services), diffusion of information-related technologies appears to increase optimal firm size.

[38]On the determinants of the boundaries of the firm, see R. Coase, "The Nature of the Firm," Economica, 4 (November 1937), 386-405; also O.E. Williamson, Markets and Hierarchies (Free Press: New York, 1975).

fact, durable goods manufacturers, have increased their investment in information equipment (as a share of total equipment investment) somewhat more slowly than wholesalers and retailers, and financial service providers.

Table 12
Investment in Information Processing and Related Equipment
(Share of Total Equipment Investment by Sector)

	1975	1980	1985	1990	1991	1992	1993
Durable Goods	14.4	21.5	28.9	27.6	27.3	28.9	27.5
Nondurable Goods	19.6	22.0	23.1	24.6	27.2	28.5	27.0
Wholesale Trade	27.7	43.7	51.6	51.0	51.5	53.5	53.2
Retail Trade	11.2	29.7	37.5	38.6	39.4	41.6	40.5
Finance, Insurance & Real Estate	37.5	35.6	39.5	36.8	38.1	39.7	38.9

Source: Bureau of Economic Analysis, U.S. Department of Commerce.

Table 13 shows investment in information technology as a percentage of total equipment investment for manufacturing industries that have been especially aggressive investors in such technology. These include both high-tech industries such as Instruments and related products, which quadrupled its rate of investment in information technology between 1975 and 1985, and industries not usually considered high-tech—e.g., Textile mill products, which tripled its share of information technology investment over the same period.

Table 13
Investment in Information Processing and Related Equipment
(Share of Total Equipment Investment in Selected Industries)

	1975	1980	1985	1990	1991	1992	1993
Motor Vehicles & Equipment	3.2	5.8	10.1	9.7	9.9	10.7	10.5
Instruments & Related Products	11.3	29.2	42.2	43.6	44.2	45.5	43.3
Textile Mill Products	5.8	9.3	16.0	18.6	19.2	19.9	16.5
Printing & Publishing	13.1	18.9	24.8	24.8	25.4	28.4	26.0

Source: Same as Table 12.

DOWN-SIZING

BLS data are consistent with the expectation of down-sizing, but are not conclusive. Table 14 indicates sharp declines between 1979 and 1992 in: the average size of manufacturing establishments; the proportion of such units employing 500 or more workers; and the total number of workers employed in units with 500 or more workers. However, the data do not track the experience of particular reporting units; so, what looks

like down-sizing could also be a reflection of the rapid growth of smaller units or the virtual disappearance of some larger ones. Accelerated change in the 1989-93 period also reflects cyclical factors.[39]

Table 14
Employment in Manufacturing by Size of Reporting Unit
(Thousands)

	Number of workers			Percent of Employment		
	1979	**1989**	**1993**	**1979**	**1989**	**1993**
Total employment	20,971	19,376	17,981	100	100	100
Employment in units with:						
less than 100 workers	4,922	5,291	5,382	23	27	30
100 to 499 workers	6,599	6,544	6,255	31	34	35
500 or more workers	9,452	7,542	6,343	45	39	35
Workers by size of units						
less than 100 workers	4921	5291	5381	24	27	30
100-499 workers	6599	6544	6255	32	34	35
500 or more workers	9453	7541	6343	45	39	35
Average number of workers per unit	64.2	52.6	46.0	NA	NA	NA
Establishments (thousands)	326.6	368.1	390.7	NA	NA	NA

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

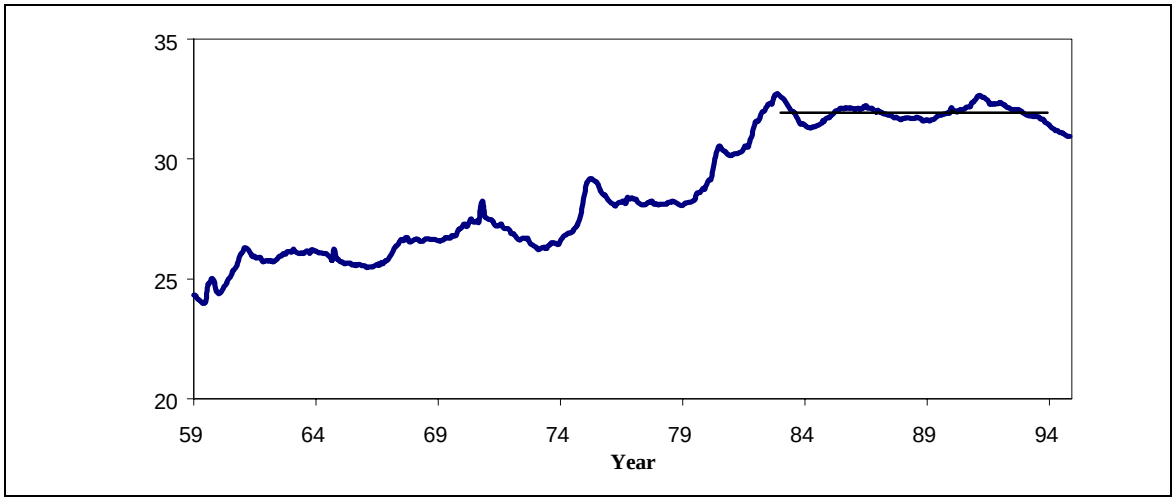
FLATTENING HIERARCHIES—CHANGES IN THE COMPOSITION OF THE MANUFACTURING LABOR FORCE

The dismantling of managerial pyramids may be reflected in the changing occupational composition of the manufacturing labor force. Figure 2 shows a steady upward trend in the relative importance of white collar job categories from 1959 until the early 1980s. The trend line flattens during 1982-90, and then turns downward.

[39]The American Management Association's 1994 AMA Survey On Downsizing lends support to the official data. The survey shows a continuing trend to reduce permanent employment among respondent companies in all sectors of the economy over the past five years. The percentage of firms reporting employment reductions increased from 36 percent in 1989-90 to 46 percent in 1990-91, then increased gradually from 46 to 47 percent from 1991-92 to 1993-94. Seventy-two percent of the AMA's 713-firm sample had down-sized at least once since January 1989. Importantly, two-thirds of the reporting companies that cut jobs somewhere in their operations in 1993-94 also created jobs in other divisions, functions, or localities. In fact, some firms in the group had net job gains during 1993-94. Average *net* change in employment for the group as a whole was -5.2 percent. A majority of respondents described their workforce reductions as strategic or structural, not a reflection of near-term market conditions. Participants in the survey are AMA member companies—i.e., firms with sales of $10 million or more, that are about evenly distributed between manufacturing and non-manufacturing industries.

Further support for this view comes from the American Management Association's 1994 Survey On Downsizing. Respondents report that hourly jobs constituted a declining share of total job cutbacks in both the 1992-93 and 1993-94 periods. In 1993-94, only 38 percent of jobs eliminated were hourly positions (compared with 47 percent in 1992-93, and 57 percent in 1991-92); remaining cuts were in supervisory, middle management, and professional/technical positions.[40]

Figure 2
Nonproduction Workers
(Percent of Total Manufacturing)



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

[40]The AMA survey is discussed in footnote 39, above. See also Kenneth Chilton, The Global Challenge for American Manufacturers, Policy Study Number 120, Center for the Study of American Business at Washington University (April 1994}. Chilton's study, summarized in Manufacturing Competitiveness Frontiers, Illinois Institute of Technology (July/August 1994), 25-32, is based on a survey of 40-50 of the center's mailing list executives and interviews with a dozen other executives. About 90 percent reported working more closely with suppliers and customers; 96 percent "view the past five years as a time of important structural change at their firms"; and 70 percent agreed that their firms had "greatly reduced the number of layers in its hierarchy."

It should be noted that the recent increase in the relative importance of blue collar job categories can also be explained by factors other than changes in corporate structure—e.g., recovery from the 1990-91 recession (blue collar job categories generally expand more rapidly than white collar categories during cyclical up-turns); or the shifting fortunes of the automobile and aircraft industries. Traditionally, production workers have constituted nearly 80 percent of the labor force in the resurgent auto industry, and only about 50 percent of the labor force in the troubled aircraft industry.

OTHER CHANGES IN CORPORATE STRUCTURE—THE TREND TOWARD VIRTUAL COMPANIES

The ability to move information cheaply and quickly through digital networks also appears to be blurring the distinction between what is *inside* and *outside* the firm. Information systems such as the *just in time* and other quick response inventory systems are allowing suppliers to restock customers on the basis of information communicated via shared networks. In such cases, arm's length relationships between buyers and sellers have given way to symbiosis and the breakdown of formal boundaries. This phenomenon is being carried to even greater extremes through the advent of networked production or the *virtual company*, in which different firms allocate among themselves different tasks of an enterprise and use their shared information flows to coordinate their activities as if they were one organization at the moment of production.

In effect, under the combined pressure of increasing competition and advancing technology, firms are casting off those stages of production or marketing in which the company is not *best of class*. Instead of building integrated production chains, they are entering into a series of strategic alliances and partnerships to bring them what they cannot make for themselves on a best-of-class basis, recreating through partnership and alliance what once resided within the boundaries of the integrated company.

The trend toward virtual companies implies a greater potential for skill specialization in an individual firm, the elimination of possible cross-subsidies among the activities of a firm, and a higher level of competition in general. In essence, each of a firm's operations and each of the stages of its production process is subject to competitive *entry*. Thus, competition has been transformed from a contest of scale-driven companies who seek to avoid ceding any niche or segment to their competitors to a contest among highly focused firms who identify and leverage their compelling, world class skills into commanding positions in precisely defined activities.

Addendum on the Importance of a Domestic Manufacturing Base

Evidence and analysis presented in Part I support the conclusion that manufacturing industries have a strategic role in the growth process. Still unanswered, however, is the question of whether the benefits of goods production to any nation's economy are diminished when the production happens off shore. Why, for example, should the productivity enhancing effects of an inventory tracking system depend on nationality of the operating hardware?

Though they do not meet strict tests of scientific proof, two arguments for the economic importance of a strong domestic manufacturing base appeal powerfully to common sense: (i) that a strong manufacturing base is essential to balanced trade; and (ii) that manufacturing industries are geographically linked to high-value-added services. The concluding sections of this study address these arguments.

Manufacturing and Balanced Trade

Until recently, it seemed self-evident that developed nations needed commercially strong goods-producing sectors to balance their external accounts and to provide entree to opportunities created by world-wide economic growth.

The idea that goods are, and are likely to remain, the principal currency of international trade is based partly on the view that goods are inherently more portable than services (many of which must be consumed where and as they are produced), and partly on practical experience. In 1987, for example, the balance in the U.S. merchandise trade account reached minus $152 billion; manufactures alone accounted for 82 percent of the shortfall. In the same year, the nation's trade balance in private services stood in significant if comparatively modest surplus, at $13 billion. But exports of private services equaled only about 25 percent of total U.S. goods and services exports.[41]

Since 1987, of course, America's export potential has proven to be deeper and more diverse than expected. U.S. manufacturing firms have experienced a remarkable competitive resurgence—thanks partly to changes in exchange rates. Even more significantly, net exports of private services have mushroomed (to about $60 billion in 1993).[42]

U.S. competitiveness in the world's growing service markets has challenged the view that, as a practical matter, developed economies must have strong manufacturing industries to

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[41]Given these facts, it seemed reasonable to assume that a solution to America's trade problems would have to be found in manufacturing. In a speech at Yale University in November 1985, then-Federal Reserve Board Chairman Paul Volker suggested that to eliminate the trade deficit in five years, improvement would have to come "almost entirely in manufactured goods...[assuming that] changes in agricultural and oil trade balance out...." Volker did not consider the possibility that service exports might affect the mix in a serious way.

[42]For data on manufacturing exports, see U.S. Department of Commerce, International Trade Administration, U.S. Foreign Trade Highlights 1991 (Washington, D.C.; 1992), 9. Data on services exports are published by the Commerce Department's Bureau of Economic Analysis in the Survey of Current Business (SCB). SCB, (June 1993) 70-71, and (December, 1994) 43, reports that between 1980 and 1993, U.S. merchandise exports (exclusive of military goods) increased by 96 percent; while U.S. exports of private services increased by 340 percent.

The idea that strong manufacturing industries are essential to advantageous participation in international commerce has at least two corollaries: (i) that exposure to global competition forces manufacturing industries to increase productivity more quickly than industries outside the trade sector—to the ultimate benefit of the economy at large; and (ii) that access to foreign markets gives manufacturing industries opportunities for output and job growth that are unavailable to industries outside the trade sector. As has been suggested, however, these advantages do not apply to manufacturing industries alone, but also to those service industries that are accounting for an increasing share of U.S. trade.

keep their external accounts in balance. This raises the possibility that some nations may now be able to support substantial deficits in their manufactures trade over indefinite periods by exporting high-value services.

The question for these nations is whether such a solution is sustainable over time—i.e., whether service industries can remain world-class for long without close physical proximity to world-class manufacturing industries.[43]

Manufacturing Industries and High-Value Services

Theoretically, if major segments of manufacturing are standardized and/or highly automated, nations should be able to accelerate overall economic growth by shifting resources to high-value-added service industries (e.g., as some small countries specializing in financial service appear to have done). An alternative view—often associated with the Berkeley Roundtable on International Economics (BRIE)—holds that this theory fails to consider how production is really organized.

According to BRIE, *manufacturing [domestically] matters* because high-value-added services (e.g., software design, communication systems development) are geographically linked to key manufacturing operations (e.g., computer production). These services are not a substitute for manufacturing; they complement manufacturing. When the manufacturing operations move off-shore, the service operations ultimately follow. Therefore, unlike an earlier era when nations achieved rapid growth by shifting resources from agriculture to industry, today developed nations that shift resources out of manufacturing and into high-value-added services ultimately experience slower growth.[44]

These arguments appeal persuasively to common sense. Their principal weakness—acknowledged by proponents themselves—is that they rest on a narrow base of evidence. It is not clear, for example, whether geographic proximity to manufacturing customers is important for all manufacturing industries and operations, and all high-value-added

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[43]A second issue, inherent in the idea that manufacturing industries have a special role in economic growth, is that while service exports help the trade balance, dollar-for-dollar they may be less valuable than manufactured exports to the economy at large.

[44]See, for example, Cohen and Zysman, op. cit.; also "Manufacturing Innovation and Industrial Competition," Science (March 4, 1988), 1110-14. The authors illustrate their point with an example from agriculture. If the farm moves off shore, they say, the crop-duster will follow, along with the large animal veterinarian. "Many high value added service jobs are functional extensions of an ever more elaborate division of labor in production. The shift we are experiencing is not from an industrial economy to a post-industrial economy, but rather to a new kind of industrial economy"(1114).

It should be added here—for those who look to U.S. competitiveness in service to compensate entirely for the chronic imbalance in our manufactures trade—that high-value-added service exports are often tied to cross-border sales of manufactured goods.

services, or only a subset of these. Nor is it clear whether the manufacturing-services nexus varies in intensity from country to country.[45]

BRIE's linkage argument finds some support in Michael Porter's more comprehensive *cluster* theory of industrial competitiveness. In The Competitive Advantage of Nations (1990), Porter arrays an impressive body of case evidence to show that physical proximity to world-class suppliers and the existence of a sophisticated near-by customer base are important common characteristics of globally competitive corporations.[46] Emphasis on proximity to suppliers and customers is also implicit in modern management principles such as just-in-time and total quality management. The idea is somewhat at odds, however, with another current development in the organization of production—i.e., globalization.

In the end, Porter's theory and the evidence on which it rests do not offer a satisfying answer to the question whether a strong national economy requires strong *domestic* manufacturing industries. One reason for this is that his research deals largely with manufacturing industries, not the link between manufacturing and services. Moreover, his main interest is in what makes national industries competitive, not in what happens when they begin to fail. Also, while all of the determinants of competitiveness in his system are important, some (e.g., vigorous local competition) appear to be more important than others, and strength in one area can compensate for weakness in another.

Thus, while Porter's theory is consistent with the manufacturing matters argument, and while it certainly argues for careful assessment of the determinants of competitiveness in high-value-added service industries, it is not a basis for *predicting* that competitiveness in U.S. service industries will decline as a consequence of competitive weakness in related areas of U.S. manufacturing.

In summary, therefore, despite its appeal to common sense, the argument that manufacturing production must be on-shore to keep the home economy strong invites reasonable questions—and further examination.

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[45]Cohen and Zysman observe (1112): "At present only limited systematic evidence exists to demonstrate that production organization differs sharply between countries, let alone that such differences are crucial to the success of firms." In fact, proponents of the *manufacturing matters* view sometimes criticize foreign direct investment in U.S. manufacturing operations on the grounds that the associated highly-paid service jobs remain in the home country.

Robert Solow recognized both the power and common sense quality of the manufacturing-matters argument at a roundtable discussion of the Joint Economic Committee on September 25, 1991. "I have a gut sympathy, first of all," he said, "with the feeling that we ought not be calm in the face of the loss of the manufacturing base. I put it that way because it is surprisingly hard to find a good, intellectual justification for distinguishing between manufacturing and financial services, or some other sort of service. I have placed my mind, such as it is, at the service of my gut, such as it is, and I think you can make a sound case that manufacturing has some special qualities. For instance, if you lose the manufacturing base you are sure as hell going to lose those services that serve manufacturing."

[46]See especially Chapter 3, "Determinants of National Competitive Advantage." Other important determinants in Porter's theory include the presence of highly specialized pools of labor and technology, and vigorous local competition.

CONCLUSION

A well established body of theoretical and empirical research supports the conclusion that manufacturing industries are engines of growth. These industries are by far the economy's most prolific generators and disseminators of new technology. In addition, manufacturing integrates more numerous and varied inputs of goods and services and cultivates a greater variety of production skills than other kinds of production activity.

The new face of American manufacturing reflects a process of relentless change in the composition of production, the mix of skills required, and the organization of U.S. manufacturing firms:

- Recent experience shows that manufacturing industries do not grow stronger (or weaker) together, in step with some inevitable rhythm of economic history. Rather, growth is concentrated in a group of industries that gain output share quickly, displacing predecessors and creating new venues for enterprise and employment.

- Though manufacturing industries have supplied a relatively constant share of GDP for decades, the direct link between growth in manufacturing output and the spread of economic opportunity is now more tenuous. Manufacturing accounts for a steadily declining share of total U.S. employment (though in many manufacturing industries, productivity, output, and employment have grown in tandem). Proportionately fewer jobs are concentrated in blue collar categories. And erosion in the average wage of manufacturing workers relative to service workers contradicts the common assumption that manufacturing jobs are, by definition, *good jobs*.

- In recent decades, the intensification of global competition and epochal advances in information technology have begun to favor business organizations that are smaller, flatter, and more flexible than their predecessors. On average, manufacturing establishments are smaller than they were ten years ago, and they employ fewer mid-level managers. Moreover, some evidence suggests that the information revolution has spawned new systems of networked production in which small specialized firms use shared information to coordinate their activities, simulating the performance of much larger integrated companies.

These findings leave little doubt that the manufacturing sector is a powerful source and a principal arena of growth and change. They provide only limited guidance, however, on an important related question: Whether the benefit of goods production to any nation's

economy is diminished when the production happens off shore. On this question, at least, the judgment of the present study is an invitation to further research.

Appendix

Table A 1
Thirty Fastest Growing Manufacturing Industries
by Gross Output
(Average Annual Growth Rates)

Industry	1981-90		1960-90	
	Growth	Rank	Growth	Rank
Computer equipment	**23.1**	**1**	**23.9**	**1**
Ammunition and ordnance, ex. small arms	**11.0**	**2**	**5.3**	**16**
Misc. publishing	**9.9**	**3**	**5.7**	**13**
Semiconductors and related devices	**9.4**	**4**	**16.4**	**2**
Guided missiles and space vehicles	**8.6**	**5**	**2.4**	**70**
Misc. electronic components	**8.2**	**6**	**7.0**	**6**
Boat building and repairing	**8.1**	**7**	**5.1**	**18**
Medical instruments and supplies	**7.4**	**8**	**7.3**	**5**
Aircraft and missile parts and equipment	**7.4**	**9**	**1.9**	**86**
X-ray and other electromedical apparatus	**6.5**	**10**	**9.3**	**3**
Carpets and rugs	**6.4**	**11**	**7.0**	**7**
Misc. plastics products, n.e.c.	**6.2**	**12**	**8.0**	**4**
Office and misc. furniture	**6.0**	**13**	**4.9**	**21**
Commercial printing and business forms	**5.7**	**14**	**4.0**	**31**
Broadcasting and communications equipment	**5.6**	**15**	**5.9**	**11**
Automotive stampings	**5.5**	**16**	**2.5**	**64**
Search and navigation equipment	**5.5**	**17**	**5.4**	**15**
Millwork and structural wood members, n.e.c.	**5.4**	**18**	**3.8**	**35**
Storage batteries and engine electrical parts	**5.2**	**19**	**4.0**	**32**
Opthalmic goods	**5.2**	**20**	**5.1**	**19**
Electrical equipment and supplies n.e.c.	**4.9**	**21**	**5.9**	**10**
Greeting card publishing	**4.6**	**22**	**4.4**	**24**
Motor vehicles and car bodies	**4.4**	**23**	**4.2**	**28**
Misc. chemical products	**4.3**	**24**	**3.5**	**40**
Jewelry, silverware and plated ware	**4.2**	**25**	**2.7**	**59**
Motor vehicle parts and accessories	**4.2**	**26**	**0.2**	**108**
Misc. petroleum and coal products	**4.1**	**27**	**3.2**	**47**

Industry	1981-90		1960-90	
	Growth	Rank	Growth	Rank
Misc. fabricated textile products	**4.1**	**28**	**3.9**	**33**
Metal services, n.e.c	**4.0**	**29**	**4.0**	**30**
Truck and bus bodies, trailers and motor homes	**3.9**	**30**	**4.2**	**26**
Total Manufacturing Industries	**2.8**	**--**	**2.8**	**--**
Total Thirty Fastest Growing Industries	**7.8**	**--**	**4.7**	**--**

Source: Bureau of Labor Statistics, U.S. Department of Labor and Bureau of Economic Analysis, U.S. Department of Commerce.

Table A 2
Thirty Slowest Growing Manufacturing Industries
by Gross Output
(Average Annual Growth Rates)

Industry	1981-90		1960-90	
	Growth	Rank	Growth	Rank
Mining and oil field machinery	**-13.5**	**1**	**-0.3**	**4**
Ship building and repairing	**-5.3**	**2**	**1.5**	**26**
Footwear, exc. rubber and plastics	**-4.9**	**3**	**-2.4**	**1**
Railroad equipment	**-4.5**	**4**	**-0.3**	**5**
Iron and steel foundries	**-4.3**	**5**	**-0.1**	**7**
Construction machinery	**-3.0**	**6**	**1.2**	**16**
Farm and garden machinery	**-2.4**	**7**	**2.1**	**34**
Blast furnaces and basic steel products	**-2.3**	**8**	**-0.5**	**3**
Primary nonferrous metals	**-2.1**	**9**	**1.2**	**15**
Forgings	**-2.1**	**10**	**-0.2**	**6**
Luggage, handbags and leather products, n.e.c.	**-1.5**	**11**	**-0.5**	**2**
Mobile homes	**-1.5**	**12**	**4.5**	**93**
Metalworking machinery	**-1.0**	**13**	**1.4**	**21**
Tobacco manufactures	**-0.9**	**14**	**0.4**	**9**
Stampings, exc. furniture	**-0.5**	**15**	**0.9**	**11**
Electric distribution equipment	**-0.5**	**16**	**2.1**	**35**
Material handling machinery and equipment	**-0.3**	**17**	**2.3**	**44**
General industrial machinery	**-0.3**	**18**	**2.2**	**38**
Engine and turbines	**-0.2**	**19**	**2.9**	**63**
Agricultural chemicals	**-0.1**	**20**	**3.4**	**75**
Office and accounting machines	**-0.1**	**21**	**3.0**	**65**
Metal cans and shipping containers	**0.0**	**22**	**1.5**	**23**
Nonferrous rolling and drawing	**0.1**	**23**	**2.2**	**37**
Nonferrous foundries	**0.3**	**24**	**1.2**	**14**
Fabricated structural metal products	**0.4**	**25**	**2.2**	**39**
Electrical industrial apparatus	**0.4**	**26**	**2.3**	**43**
Stone, clay and misc. minerals products	**0.4**	**27**	**1.1**	**12**
Sugar and confectionery products	**0.6**	**28**	**1.5**	**24**
Misc. fabricated metal products	**0.6**	**29**	**2.6**	**55**
Alcoholic beverages	**0.6**	**30**	**2.8**	**62**
Total Manufacturing Output	**2.8**	**--**	**2.8**	**--**
Total Thirty Slowest Growing Industries	**-1.2**	**--**	**1.3**	**--**

Source: Same as Table A 1.

Table A 3
Thirty Fastest Growing Industries by Output
Sources of Output Growth, 1977-1987

Industry	Growth Rate	Growth from:		Growth of Output by Type of Final Demand				
	77 to 87	Interindustry Demand	Final Demand	Household Demand	Investment Demand	Government Demand	Export Demand	Import Demand
Computer equipment	33.2	3.4	29.8	1.4	21.7	6.0	15.3	-14.5
Ammunition and ordnance	11.1	1.4	9.6	0.1	0.5	10.0	-0.5	-0.5
Misc. publishing	8.2	4.7	3.4	2.8	0.3	0.5	0.3	-0.5
Semiconductors and related devices	16.0	5.1	10.9	1.8	6.8	5.5	9.1	-12.2
Guided missiles and space vehicles	8.6	1.9	6.7	0.1	0.6	6.0	0.4	-0.3
Misc. electronic components	7.7	-2.1	9.8	2.5	7.0	3.6	5.2	-8.4
Boat building and repairing	5.4	2.9	2.5	3.2	-0.3	0.3	0.2	-0.9
Medical instruments and supplies	7.7	1.8	5.8	2.1	2.9	1.0	0.5	-0.7
Aircraft and missile parts	10.0	2.9	7.2	0.2	0.8	4.8	3.1	-1.7
X-ray and electromedical apparatus	4.4	0.3	4.1	0.6	3.4	0.5	1.9	-2.4
Carpets and rugs	3.9	1.0	2.8	1.8	1.8	0.1	0.1	-1.0
Misc. plastics products, n.e.c.	5.6	2.6	3.0	2.0	1.5	0.7	1.0	-2.2
Office and misc. furniture	6.5	0.5	6.0	1.0	5.6	1.2	0.2	-1.9
Commercial printing, business forms	5.0	2.0	3.0	2.3	0.3	0.7	0.4	-0.6
Broadcasting and comm. equipment	6.9	0.0	6.9	1.0	3.2	4.2	1.0	-2.5
Automotive stampings	0.8	-0.3	1.1	1.6	0.8	0.3	0.4	-2.1
Search and navigation equipment	11.7	1.0	10.7	0.2	3.7	6.7	0.9	-0.8
Millwork and structural wood mem.	4.1	2.1	2.0	0.2	1.6	0.2	0.1	-0.1
Storage batteries and engine parts	2.1	1.0	1.0	2.2	0.8	0.4	0.9	-3.3
Opthalmic goods	2.1	-0.4	2.5	5.8	0.4	0.3	0.8	-4.7
Electrical equipment and supplies	8.1	0.0	8.1	3.6	2.9	2.4	2.3	-3.2
Greeting card publishing	6.3	0.2	6.1	5.4	0.8	0.1	0.1	-0.3
Motor vehicles and car bodies	0.5	-0.3	0.8	1.8	1.2	0.3	0.0	-2.6
Misc. chemical products	3.9	1.7	2.2	1.9	0.5	0.6	0.8	-1.6
Jewelry, silverware and plated ware	0.8	0.6	0.2	6.0	-0.2	0.1	0.7	-6.4
Motor vehicle parts and accessories	-1.1	-0.9	-0.1	1.8	0.8	0.3	-0.2	-2.9
Misc. petroleum and coal products	2.3	0.3	2.0	0.9	0.7	0.7	0.3	-0.6
Misc. fabricated textile products	3.3	1.6	1.8	2.7	0.5	0.3	0.1	-1.8
Metal services, n.e.c	3.4	-1.0	4.4	1.2	3.0	1.6	1.9	-3.3
Truck and bus bodies and motor homes	0.9	0.6	0.3	0.1	0.8	0.1	0.0	-0.6
Thirty Fastest Growing Industries	7.7	1.1	6.6	1.4	3.4	2.4	2.3	-2.8
Total Manufacturing	1.7	-0.6	2.3	1.5	1.0	0.7	0.8	-1.8

Note: Industries that ranked in the top 30 from 1977 to 1987, but are not shown include: Aircraft, Aircraft and missiles, Measuring devices and watches, Blankbooks and binding, Drugs, Paperboard containers and Periodicals.

Source: Bureau of Labor Statistics, US. Department of Labor (based on BEA data).

Table A 4
Thirty Slowest Growing Industries by Output
Sources of Output Growth, 1977-1987

Industry	Growth Rate	Growth from:		Growth of Output by Type of Final Demand				
	77 to 87	Interindustry Demand	Final Demand	Household Demand	Investment Demand	Government Demand	Export Demand	Import Demand
Mining and oil field machinery	-9.1	-2.9	-6.3	0.4	-5.8	0.1	-0.6	-0.3
Ship building and repairing	-2.5	-0.4	-2.2	0.2	-2.3	-0.1	-0.1	0.0
Footwear, exc. rubber and plastics	-4.7	-0.1	-4.6	5.1	-0.3	0.0	0.3	-9.8
Railroad equipment	-9.6	-2.4	-7.2	0.4	-6.4	0.4	-0.1	-1.5
Iron and steel foundries	-5.0	-5.0	0.0	1.0	0.5	0.6	-0.2	-1.8
Construction machinery	-5.1	-1.4	-3.7	0.2	-1.2	0.0	-1.5	-1.2
Farm and garden machinery	-5.9	-1.3	-4.6	0.4	-4.0	0.0	-0.7	-0.3
Blast furnaces and basic steel prod.	-3.9	-5.2	1.3	1.2	0.9	0.7	0.3	-1.8
Primary nonferrous metals	-3.6	-8.2	4.6	1.7	1.8	1.2	1.6	-1.8
Forgings	-2.9	-3.4	0.5	0.9	-0.2	1.4	0.3	-1.9
Luggage, handbags and leather prod.	-3.2	-0.6	-2.5	4.2	-0.1	0.1	0.3	-7.0
Mobile homes	-1.1	0.0	-1.1	0.0	-1.0	0.0	-0.1	0.0
Metalworking machinery	-1.6	-0.8	-0.7	0.5	0.0	0.5	0.4	-2.1
Tobacco manufactures	0.4	-0.2	0.6	0.8	-0.2	0.0	0.1	-0.2
Stampings, exc. furniture	0.0	-3.7	3.7	1.3	2.4	1.1	1.6	-2.7
Electric distribution equipment	-1.2	-1.9	0.6	0.4	0.1	0.6	0.4	-0.9
Material handling machinery	-0.2	-0.2	0.0	0.3	1.1	0.2	-0.1	-1.6
General industrial machinery	-1.4	-0.5	-0.9	0.5	0.9	0.3	0.0	-2.7
Engine and turbines	-2.7	-0.8	-1.9	0.8	-1.0	0.1	-0.4	-1.6
Agricultural chemicals	0.7	-2.0	2.6	1.8	0.3	-0.3	1.6	-0.6
Office and accounting machines	1.1	-3.2	4.3	0.7	3.1	1.2	2.0	-2.6
Metal cans and shipping containers	-1.6	-3.5	1.9	1.9	0.1	0.2	0.4	-0.6
Nonferrous rolling and drawing	-0.2	-3.0	2.8	1.0	1.9	1.0	1.4	-2.5
Nonferrous foundries	1.1	-1.1	2.1	1.1	1.4	1.1	0.9	-2.4
Fabricated structural metal products	0.7	-0.5	1.2	0.4	0.6	0.6	0.1	-0.5
Electrical industrial apparatus	0.0	-4.0	4.0	1.0	3.5	1.3	2.0	-3.8
Stone and clay products	-0.7	-2.1	1.4	1.0	1.2	0.6	0.5	-1.9
Sugar and confectionery products	0.0	-3.2	3.2	1.3	0.1	0.1	0.3	1.4
Misc. fabricated metal products	0.1	-1.0	1.1	1.0	0.9	0.7	0.5	-1.9
Alcoholic beverages	0.7	-0.6	1.3	1.5	0.0	0.1	0.2	-0.5
Thirty Slowest Growing Industries	-1.4	-2.3	0.9	1.2	0.4	0.4	0.5	-1.6
Total Manufacturing	1.7	-0.6	2.3	1.5	1.0	0.7	0.8	-1.8

Source: Same as Table A 3.

Table A 5
Thirty Fastest Growing Manufacturing Industries by Employment
1981-90

	Average Annual Rate of Net Job Growth
Miscellaneous publishing	**5.9**
Aircraft and missile parts and equipment	**4.9**
Millwork and structural wood members, nec	**4.9**
Boat building and repairing	**3.9**
Guided missiles and space vehicles	**3.7**
Periodicals	**3.7**
X-ray and other electromedical apparatus	**3.6**
Ammunition and ordnance, except small arms	**3.4**
Printing trade services	**3.2**
Office and miscellaneous furniture and fixtures	**3.2**
Partitions and fixtures	**3.1**
Miscellaneous plastics products, nec	**3.0**
Commercial printing and business forms	**3.0**
Medical instruments and supplies	**2.8**
Truck and bus bodies, trailers, and motor homes	**2.6**
Books	**2.0**
Carpets and rugs	**2.0**
Drugs	**2.0**
Meat products	**1.9**
Miscellaneous fabricated textile products	**1.9**
Metal services, nec	**1.8**
Blankbooks and bookbinding	**1.6**
Newspapers	**1.3**
Converted paper products except containers	**1.2**
Storage batteries and engine electrical parts	**1.0**
Motor vehicle parts and accessories	**1.0**
Search and navigation equipment	**1.0**
Aircraft	**1.0**
Soap, cleaners, and toilet goods	**0.9**
Miscellaneous food and kindred products	**0.9**
Thirty Fastest Growing Industries	**2.2**
Total Manufacturing	**-0.6**

Note: The BLS employment data used in this section include the number of payroll jobs (as opposed to employed persons) in all private non-agricultural establishments, the self-employed and unpaid family workers in industry, as well as farm workers

and private household workers. These data make no distinction between full-time and part-time positions, nor do they take into account that one person may hold two or more jobs.

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

Table A 6
Thirty Slowest Growing Manufacturing Industries by Employment
1981-90

	Average Annual Rate of Net Job Growth
Mining and oil field machinery	**-10.3**
Footwear, except rubber and plastic	**-7.2**
Blast furnaces and basic steel products	**-6.5**
Construction machinery	**-5.7**
Railroad equipment	**-5.3**
Office and accounting machines	**-4.7**
Iron and steel foundries	**-4.5**
Engines and turbines	**-4.4**
Luggage, handbags, and leather products, nec	**-4.3**
Farm and garden machinery	**-4.1**
Petroleum refining	**-4.1**
Ship building and repairing	**-4.0**
Tobacco products	**-3.9**
Primary nonferrous metals	**-3.9**
Metal cans and shipping containers	**-3.7**
Photographic equipment and supplies	**-3.5**
Electrical industrial apparatus	**-3.4**
Telephone and telegraph apparatus	**-3**
Weaving, finishing, yarn, and thread mills	**-2.9**
Alcoholic beverages	**-2.8**
Forgings	**-2.8**
Stampings, except automotive	**-2.8**
Small arms and small arms ammunition	**-2.7**
Household audio and video equipment	**-2.7**
Household appliances	**-2.7**
Tires and inner tubes	**-2.6**
Apparel	**-2.5**
Agricultural chemicals	**-2.5**
Measuring and controlling devices; watches	**-2.4**
Electrical equipment and supplies, nec	**-2.2**
Thirty Slowest Growing Industries	**-3.7**
Total Manufacturing	**-0.6**

Source: Same asTable A 5.

Table A 7
Thirty Fastest Growing Industries by Employment
Sources of Employment Growth, 1977-87

Industry	Growth Rate	Growth from:		Growth of Output by Type of Final Demand				
	77 to 87	Interindustry Demand	Final Demand	Household Demand	Investment Demand	Government Demand	Export Demand	Import Demand
Miscellaneous publishing	5.9	2.5	3.4	2.8	0.3	0.5	0.3	-0.5
Aircraft and missile parts and equipment	7.7	0.6	7.1	0.2	0.8	4.7	3.1	-1.7
Millwork and structural wood members, nec	4.2	2.3	2.0	0.2	1.6	0.2	0.1	-0.1
Boat building and repairing	1.7	-0.7	2.5	3.1	-0.3	0.3	0.2	-0.8
Guided missiles and space vehicles	8.9	2.2	6.7	0.1	0.6	6.0	0.4	-0.4
Periodicals	5.0	2.7	2.3	1.8	0.3	0.4	0.3	-0.4
X-ray and other electromedical apparatus	5.0	0.9	4.1	0.7	3.4	0.5	1.9	-2.4
Ammunition and ordnance, except small arms	5.1	-4.8	9.9	0.1	0.5	10.3	-0.6	-0.5
Printing trade services	3.3	0.5	2.9	2.2	0.3	0.6	0.3	-0.6
Office and miscellaneous furniture and fixtures	3.9	-2.2	6.1	1.0	5.6	1.2	0.2	-1.9
Partitions and fixtures	2.5	-0.1	2.6	0.1	2.4	0.2	0.1	-0.1
Miscellaneous plastics products, nec	3.4	0.3	3.0	2.0	1.5	0.7	1.1	-2.3
Commercial printing and business forms	3.5	0.5	3.0	2.2	0.3	0.7	0.4	-0.6
Medical instruments and supplies	3.7	-2.1	5.9	2.0	2.9	1.0	0.5	-0.7
Truck & bus bodies, trailers, and motor homes	1.5	1.1	0.4	0.1	0.8	0.1	0.0	-0.6
Books	1.3	-1.0	2.2	1.6	0.1	0.7	0.3	-0.5
Carpets and rugs	-0.3	-3.1	2.9	1.8	1.8	0.1	0.1	-1.0
Drugs	1.7	-1.1	2.8	2.7	0.2	0.4	0.4	-0.7
Meat products	0.9	-1.3	2.2	2.2	0.1	0.1	0.2	-0.4
Miscellaneous fabricated textile products	1.0	-0.8	1.7	2.6	0.4	0.3	0.1	-1.7
Metal services, nec	1.8	-2.7	4.5	1.2	3.1	1.6	1.9	-3.4
Blankbooks and bookbinding	2.3	-0.4	2.7	2.4	0.2	0.7	0.3	-1.0
Newspapers	1.6	-0.8	2.4	2.0	0.3	0.3	0.3	-0.5
Converted paper products except containers	1.0	-1.8	2.8	2.3	0.6	0.5	0.5	-1.0
Storage batteries and engine electrical parts	-0.7	-1.8	1.1	2.2	0.8	0.4	0.9	-3.3
Motor vehicle parts and accessories	-0.7	-0.6	-0.1	1.8	0.8	0.3	-0.2	-2.9
Search and navigation equipment	5.6	-5.5	11.2	0.2	3.9	7.0	0.9	-0.8
Aircraft	2.8	-2.8	5.6	0.1	1.2	3.6	1.3	-0.7
Soap, cleaners, and toilet goods	1.6	0.0	1.6	1.6	0.1	0.1	0.3	-0.4
Miscellaneous food and kindred products	0.6	-2.7	3.4	3.3	0.1	0.1	0.5	-0.6
Thirty Fastest Growing Industries	2.5	-0.8	3.3	1.7	1.0	1.2	0.5	-1.1
Total Manufacturing	-0.3	-3.0	2.7	1.6	1.4	0.9	1.0	-2.2

Note: Industries among the top 30 from 1977-1987 but not included in this table: Computer equipment, Broadcasting and communications equipment, Semiconductors and related devices, Miscellaneous electronic components, Aircraft and missile engines, Miscellaneous chemical products.

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