The Competitiveness of U.S. Manufactured Goods: Recent Changes and Prospects

The decline in the international competitiveness of U.S. manufactured goods over most of the past decade has been much discussed. U.S. goods lost significant market share both at home and abroad. Declining manufacturing competitiveness contributed to record current account deficits, falling manufacturing employment, and almost stagnant real compensation growth for manufacturing employees.

A prime factor accounting for the decline in U.S. competitiveness was a large deterioration in the relative price position of U.S. goods.[1] The steep appreciation of the U.S. dollar between 1979-85 led to sharply rising U.S. costs and prices in comparison to those abroad. Slower growth in U.S. domestic costs and prices offered only a modest offset to the negative price effect of dollar appreciation. Weak growth in manufacturing productivity until 1982 compounded U.S. problems.

At the same time that overall dollar prices were becoming less favorable for the United States, U.S. competitiveness also suffered from significant quality problems in a number of important industries. Manufacturing competitiveness was weakened by a growing international disenchantment with the caliber of U.S. products. Although many goods maintained their strong performance reputations, sufficient questions were raised about the quality of other products to account for perhaps as much as one-quarter of the loss of U.S. competitiveness over the period 1979-86.

More recently, however, major changes have occurred, strengthening the price/cost and quality position of U.S. manufacturing. U.S. relative prices have improved sharply. This improvement reflects the steep depreciation of the dollar since 1985, continued U.S. domestic cost restraint, and a dramatic rise in U.S. productivity that started in 1982. U.S. competitiveness has been further bolstered by a substantial improvement in the quality performance of a number of important U.S. products and the introduction of significant quality control measures across the broad spectrum of U.S. manufactured goods.

This paper explores these recent favorable changes in the competitiveness of U.S. manufactured goods. It first considers the extent to which U.S. price and quality performances have improved, focusing on the effects of exchange rate movements, cost restraint, productivity increases, and quality control efforts. The paper then analyzes in more detail how certain underlying factors —investment levels, technology/research and development expenditures, industrial restructuring, and work reorganization—have changed, promoting the improvement in the U.S. position. Finally, the paper discusses the implications of recent and expected changes in these underlying factors for the competitiveness of U.S. manufactured goods over the next several years.

[1]For a detailed accounting of the factors causing the decline in U.S. competitiveness over both the 1973-86 and 1979-86 periods, see Susan Hickok, Linda Bell, and Janet Ceglowski, "U.S. Manufactured Goods Competitiveness: Recent Changes and Future Prospects," Federal Reserve Bank of New York, Research Paper no. 8801, February 1988.

Recent competitiveness changes

Price performance: exchange rates and domestic costs

Performance relative to other industrial countries: After losing significant price competitiveness to major foreign industrial countries during the early 1980s, U.S. manufacturers experienced a sharp reversal in their relative price position in the last two years. For the period 1980-85 the price of foreign manufactured goods fell on average 5 percent a year relative to U.S. prices when measured in dollar terms. But in 1986 U.S. prices fell 17 percent on a year average basis against competing foreign industrial country prices (Chart 1).[2] U.S. prices continued to improve in 1987 as well, regaining their pre-1980 competitive position on a year average basis. By December 1987 U.S. prices were actually about 10 percent more competitive than they had been at the end of 1979.

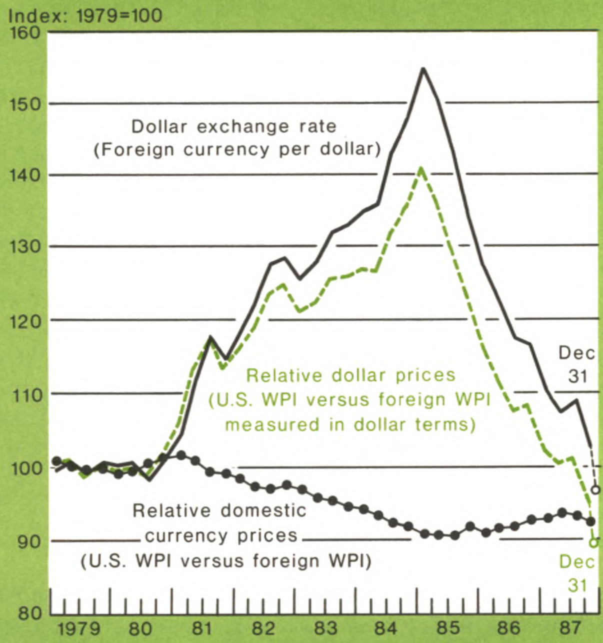
Both exchange rate changes and domestic price movements, backed by changes in domestic input costs and productivity levels, accounted for this improvement. Exchange rate changes had the most obvious effect. Since mid-1985 the dollar has depreciated 30 percent against major foreign currencies, a decline that totally reverses the 30 percent depreciation of these foreign currencies against the dollar during the period from 1980 to early 1985.

Also affecting U.S. price competitiveness critically in the 1980s, albeit less dramatically, were changes in the price levels of manufactured goods measured in local currency terms in different industrial countries. Despite starting the 1980s at a higher rate than the average rate abroad, U.S. price inflation was significantly lower than average foreign inflation for the 1980-87 period as a whole. The greater moderation in U.S. inflation mitigated to some extent the negative competitiveness impact of dollar appreciation during the 1980-85 period. And by the beginning of 1988, with the dollar returned to its pre-appreciation level, it was the movement in relative domestic prices that placed the United States in a 10 percent stronger price competitive position than at the start of the decade.

Input price movements, especially restrained U.S. wage growth, were important contributing factors to the more subdued movement of U.S. domestic prices during recent years. Over the 1980-87 period U.S. hourly compensation rates for manufacturing employees, which account for about 60 percent of the cost of manufacturing production,[3] grew on average only 5.7 percent a year, compared to an average annual foreign rate of about 8 percent (Table 1). Although both U.S. and foreign wage growth slowed markedly as the 1980s progressed, U.S. growth remained significantly below that abroad. The positive effect of wage restraint on U.S. cost is evident in a comparison of average hourly dollar compensation levels in the United States with foreign compensation levels. At the end of 1987 the dollar was back to its beginning 1980 level. End-1987 U.S. hourly compensation, however, was only slightly above average compensation abroad, in sharp contrast to its large differential in 1980.[4]

Capital costs, which along with return on investment account for about 20 percent of the cost of production, also moved in favor of U.S. price competitiveness over the last three years. The recent moderation in capital costs, however, only offset an unfavorable movement in these costs during the early 1980s. The major and most volatile component of relative marginal capital costs has

Chart 1
U.S. Relative Prices
Quarterly Averages



[2]This change in relative prices measured in U.S. dollar terms is computed by combining changes in respective wholesale price indexes with changes in exchange rates. Using GNP deflators instead of wholesale price indexes gives essentially the same results. Average foreign prices are a weighted average of Canadian, Japanese, German, French, British, and Italian prices. Weights are determined by an equal combination of each country's imports as a share of U.S. exports and each country's imports as a share of world exports.

[3]Input shares are derived from 1977 input-output tables for the United States reported in the *Survey of Current Business*, May 1984 and November 1985.

[4]Wage restraint, of course, came at the expense of the relative living standards of manufacturing employees. Improved living standards are a major goal of the overall competitiveness effort. Despite this negative effect, wage restraint did improve the price position of U.S. goods in relation to that of foreign goods during the 1980s.

been the real interest rate level.[5] After moving sharply above average foreign real interest rates during the early 1980s, U.S. real interest rates fell significantly in the mid-1980s, reaching average foreign levels by 1986 (Chart 2). They remained in line with foreign levels in 1987.

The cost of raw materials, the third input in manufacturing production, was the only factor working against U.S. price competitiveness in recent years. Raw materials account for about 20 percent of the cost of manufacturing production. The price of these materials is set in global markets and rises in dollar terms about equally with the level of dollar depreciation,[6] although the effects of the increase may not be felt immediately because of long-term contracts and inventories. As a consequence of the recent sharp depreciation of the dollar, raw material costs in the United States rose relative to costs in countries whose currencies have been appreciating against the dollar. This development offset slightly the price competitiveness benefits provided by dollar depreciation.

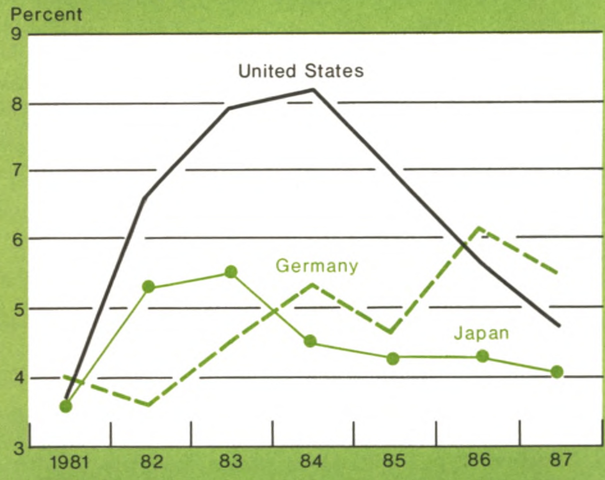
[5]Evidence supporting this point can be found in Table 2 of *A Historical Comparison of the Cost of Financial Capital*, U.S. Department of Commerce, International Trade Administration, April 1983, p. 3.

[6]A. Steven Englander, "Commodity Prices in the Current Recovery," this *Quarterly Review*, vol. 10, no. 1 (Spring 1985), pp. 11-19.

Chart 2

Real Long-Term Government Bond Yields

Annual Average of Monthly Data



Note: Interest rates deflated using consumer price indexes.

Table 1

Hourly Compensation in Manufacturing

	United States	Foreign Industrial Countries*	Germany	Japan
Average annual growth in local currency terms†				
1974-79	9.5	13.9	9.5	12.8
1980-87‡	5.7	7.9	5.6	4.6
1980-85	6.9	9.2	6.0	5.0
1986-87‡	2.3	4.3	4.7	3.1
Level of hourly compensation in U.S. dollars§				
1980	9.84	8.48	12.33	5.61
1985	12.96	8.56	9.56	6.47
1987 average‡	13.50	12.50	14.00	9.75
1987 year-end†//	13.50	13.25	15.50	11.00

*Trade-weighted average of Canada, France, Germany, Italy, Japan, and the United Kingdom. See text footnote 2 for description of weighting.

†All manufacturing employees.

‡1987 foreign figures are FRBNY estimates based on reported (although not strictly comparable) wage growth rates in foreign countries.

§Production workers.

//1987 average converted at year-end exchange rates.

Source: Bureau of Labor Statistics

Overall, input price movements clearly benefited U.S. price competitiveness. Competitiveness gains also resulted, however, from very strong improvement in U.S. manufacturing productivity. Productivity measures the amount of output produced by a given amount of input. The higher the productivity level, the greater the output that can be produced at a given input cost. Consequently, higher productivity levels mean that manufacturers can lower the price charged per unit of product while still covering the cost of production inputs.

The performances of labor and capital are closely linked in the production process. When labor has a larger or more efficient stock of capital equipment to work with, measured labor productivity (output per manhour) is higher. Similarly, when labor is more efficient, measured capital productivity (output per unit of capital) is higher. It is very difficult to separate completely growth in labor productivity from growth in capital productivity. This difficulty is compounded by the more basic problem of measuring a unit of capital. For these reasons, productivity figures are generally reported in terms of labor productivity, with the understanding that these figures reflect both labor and capital factors. This reporting practice is reasonable because capital productivity normally changes only slowly as new pieces of equipment are added to the existing capital stock.

U.S. labor productivity in manufacturing improved dramatically during the 1980s, notably from mid-1982 on.[7] Average annual productivity growth for 1983-87 was triple its 1970s level (Chart 3). By the mid-1980s productivity growth in the United States was significantly outstripping productivity growth abroad after having substantially lagged it through the 1970s and even during the early 1980s. As a consequence of its strong recent growth, the actual level of U.S. productivity has remained significantly above that of other major industrial countries (Chart 4). In fact, a translation of relative productivity levels into more concrete terms implies that output produced in about one hour of labor time in the United States last year required almost one hour and ten minutes of labor time in both Germany and Japan.[8]

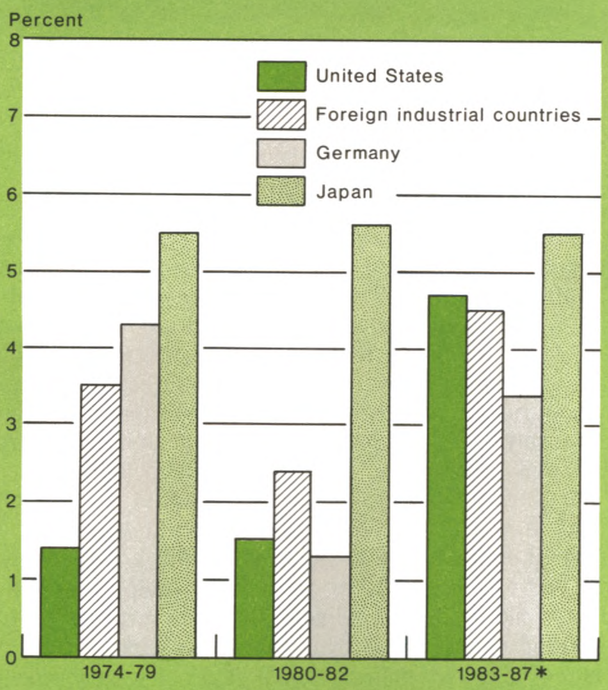
The combination of strong productivity performance, substantial wage restraint, and recent dollar depreciation has made the United States very competitive in terms of unit labor costs (labor costs per unit of output). U.S. unit labor costs have risen only very moderately for the 1980s as a whole and have actually fallen in recent years as productivity has rebounded (Table 2). U.S. output that required $100 in labor costs in 1980 cost only about $105 in 1987. In 1980 this same output cost about $120 in labor costs in Germany and $65 in labor costs in Japan. In 1985, when the dollar reached its peak appreciation level against most foreign currencies, German and Japanese unit costs fell to about $80 and $60 respectively while U.S. costs averaged $110. But

[7] Especially encouraging for a broad-based improvement in U.S. competitiveness was the distribution of the recent U.S. labor productivity growth across manufacturing industries. Durable manufactured goods industries, the laggards in productivity growth in the 1970s, experienced especially sharp productivity advances in the 1980s. In fact, recent productivity growth in these industries set a record for the post-World War II period.

[8] These figures are based on value added in manufacturing, converted into U.S. dollars at purchasing power parity exchange rates, divided by manhours worked in 1975. Figures for 1987 are derived by applying productivity growth rates provided in the sources cited in Table 2. Purchasing power parity exchange rates are from Irving Kravis, Alan Heston, and Robert Summers, *World Product and Income* (Baltimore: Johns Hopkins University Press, 1982), p. 22, Table 1-10, column 7.

Chart 3

Average Annual Growth in Manufacturing Labor Productivity

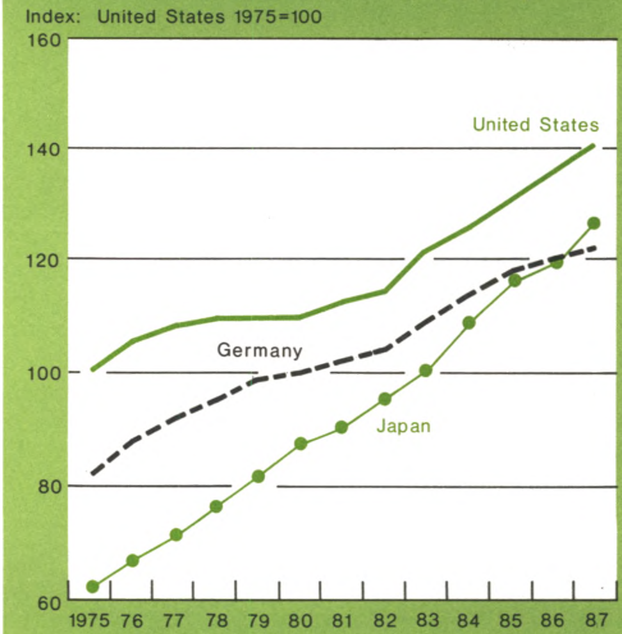


*Average for foreign industrial countries is for 1983-86; average for Japan is based on data through October 1987.

Sources: Bureau of Labor Statistics; Deutsche Bundesbank, Supplement to Monthly Report, series 4, March 1988, for German 1987 number; Statistics Bureau of the Management and Coordination Agency, Monthly Statistics of Japan, January 1988, for Japanese 1987 number.

Chart 4

Productivity Levels in Manufacturing



by 1987, following substantial dollar depreciation, German costs averaged about $140 and Japanese costs averaged about $100. By year-end 1987 further dollar depreciation brought the German cost to over $150 and the Japanese cost to about $115.[9]

In sum, the dominating factor shaping the path of U.S. price/cost competitiveness in relation to other industrial countries from 1980 until 1987 was the movement in exchange rates. However, by year-end 1987 these exchange rate movements had canceled themselves out, leaving changes in relative domestic price levels the final determinant of shifting price competitiveness positions over the seven years as a whole. Input price movements, specifically wage costs, and productivity growth rates each played a significant role in charting the course of changes in relative domestic price levels. Together these two factors left the United States in a very strong price competitive position in relation to other major industrial countries at the start of 1988.

[9]These calculations are based on hourly compensation in manufacturing divided by output/manhour (described in the preceding footnote). All calculations were done for 1975. Figures through 1986 for Germany and Japan and through 1987 for the United States were derived by applying Bureau of Labor Statistics growth rates for unit labor costs measured in dollar terms. Foreign figures for 1987 are based on reported 1987/1986 unit labor cost growth by Germany and Japan adjusted for exchange rate changes. End-1987 figures reflect end-year exchange rate changes. All figures should be regarded as approximations given the problems of obtaining strict comparability of data across countries. Similar results for 1980 were derived using slightly different methodology in Nigel Gault, "The Competitiveness of U.S. Manufacturing Industry: International Comparisons of Labor, Energy, and Capital Costs," Data Resources, Inc.

Table 2
Unit Labor Costs

	Growth in Unit Labor Costs in Local Currency Terms		
	1974-79	1980-86	1987
United States	8.0	3.2	−1.9
Foreign industrial countries*	10.1	5.2	
Germany	4.9	2.8	2.9
Japan	6.8	−0.8	−2.2

	Growth in Unit Labor Costs in U.S. Dollars		
	1974-79	1980-86	1987
United States	8.0	3.2	−1.9
Foreign industrial countries*	10.1	2.0	
Germany	4.9	0.6	24.4
Japan	6.8	3.0	19.1

	Approximate Relative Unit Labor Cost Levels in U.S. Dollars			
	1980	1985	1987 Average	1987 Year-End
United States	100	110	105	105
Germany	120	80	140	155
Japan	65	60	100	115

*Trade-weighted average of Canada, France, Germany, Italy, Japan, and the United Kingdom. See text footnote 2 for description of weighting.

Source: Bureau of Labor Statistics; Deutsche Bundesbank, *Supplement to Monthly Report*, series 4, March 1988, for German 1987 growth rate; Statistics Bureau of the Management and Coordination Agency, *Monthly Statistics of Japan*, January 1988, for Japanese 1987 growth rate. Unit labor cost levels are derived as described in text footnote 9.

Performance relative to developing countries: U.S. prices have become more competitive relative to those of developing countries in recent years. The major developing country competitors in the manufactured goods market have been the four Asian economies: Taiwan, South Korea, Hong Kong, and Singapore. These four economies account for most of the competitiveness gain, measured in terms of market share, of developing countries in relation to the United States since 1979.

Recent exchange rate movements have improved U.S. price competitiveness relative to these four Asian economies. Over the last two years, the currencies of all but Hong Kong appreciated against the U.S. dollar (Table 3). In Taiwan's case the appreciation was quite sharp. Both the Taiwanese and Singaporean currencies are now higher in value against the U.S. dollar than they were at any other time during the 1970s or 1980s.

It is more difficult to compare domestic currency price movements in these Asian economies and in the United States. Generally higher weight is given to the falling price of refined petroleum in the Asian price indexes than in the U.S. price index. Despite this difference, the combined impact of reported relative price movements and exchange rate changes still suggests that the United States moved significantly closer to its early 1980s price competitiveness position relative to these Asian economies in recent years (lower half of Table 3), reversing a sharp competitiveness deterioration earlier in the 1980s.

Quality performance

Improvement in relative quality characteristics in recent years has also had a favorable effect for U.S. competitiveness. Quality characteristics include product reliability, durability, and technological sophistication, as well as product requirements for maintenance, servicing, and delivery time. Problems in these areas are important because they affect not only purchaser satisfaction and demand; they also tend to raise costs. It has been estimated that the typical U.S. factory spends 20-25 percent of its operating budget finding and fixing defective products.[10] This estimate does not include the cost of repairing products after they have been shipped

[10]"The Quest for Quality," *Business Week*, June 8, 1987, p. 32.

from the factory. Quality problems also require maintenance of larger inventories with resultant increases in inventory costs.

Although data on costs and productivity for the United States and foreign countries are readily available, it is more difficult to find information about the relative quality of products across countries. However, cross-country quality appraisals do exist for eleven broadly defined industry groupings during the 1980s, and these show very generally how well the United States has competed in quality terms over the past few years. (Specifics of these quality appraisals are given in the Appendix.) The eleven broad industry groupings—automobiles, paper, steel, electronic parts, pharmaceuticals, construction equipment, consumer electronics, machine tools, electric power generating equipment, textile machinery, and general aviation aircraft—accounted for about 15 percent of U.S. manufactured goods output, 15 percent of U.S. manufactured goods exports, and 27 percent of U.S. manufactured goods imports in 1986.

Quality problems in U.S. products were found in five of the broad industries. However, two of these five industries had eliminated their quality deficiencies by the end of the appraisal period. U.S. quality was perceived superior to that of foreign competitors in four other industries. For the remaining two industries, U.S. quality was judged superior for some products but inferior for others.

Collectively, these results suggest that the United States had an average quality rating in the early 1980s, with some quality improvement as the decade progressed. Particularly significant for declining U.S. competitiveness in the early 1980s and increasing U.S. competitiveness in recent years was the finding that both quality problems and quality improvement appeared in some of the largest U.S. industries. For example, quality problems were recently overcome by U.S. steel and electronic parts producers, two industries that together account for 4 percent of U.S. manufactured goods output.

Anecdotal evidence also suggests a significant improvement in the quality performance of U.S. manufactured goods in recent years. The U.S. automobile industry, a major producer facing quality problems, has launched a concerted drive to boost its quality reputation. Quality control procedures have also been upgraded in many companies. Statistical methods of quality control, in particular, have gained substantial popularity.[11] These methods apply sophisticated statistical techniques to determine exactly where defects are originating in the many separate steps that go into producing a typical finished manufactured product. Increasing use has also been made of computers to "design out" quality defects when products are first created. In part for this reason, the use of computer-aided design (CAD) and computer-aided manufacturing (CAM) systems increased 400 percent from 1981 until 1986.

Additional evidence of recent quality emphasis in U.S. manufacturing comes from manufacturers' comments

[11]Major firms using statistical quality control procedures include AT&T, Corning Glass, DuPont, Ford, Hewlett-Packard, IBM, Kodak, and Westinghouse. See "The Quest for Quality," p. 32.

Table 3

Recent Changes in Asian Exchange Rates and Export Unit Values in U.S. Dollar Terms

Period Average Levels

Exchange Rates (Currency per U.S. Dollar)	**1980**	**1985**	**1986**	**1987**	**1987-IV**
Taiwan—New Taiwan dollar	36.00	39.85	37.33	31.48	29.68
South Korea—Won	607.43	870.02	881.45	823.62	803.43
Hong Kong—Hong Kong dollar	4.98	7.79	7.80	7.80	7.79
Singapore—Singapore dollar	2.14	2.20	2.18	2.11	2.05

Export Unit Values in U.S. Dollar Terms (1980=100)*	**1980**	**1985**	**1986**	**1987-III**
Taiwan	100	94.9	99.3	118.1
South Korea	100	95.5	96.9	107.1
Hong Kong	100	88.3	90.2	93.0†
United States (Finished goods producer prices)	100	118.9	117.3	120.4

*Export unit values rather than wholesale prices are used for price competitiveness comparisons for export-oriented newly industrializing countries for two reasons: 1) a wholesale price index is not available for Hong Kong, and 2) export incentives have put a wedge between export prices and wholesale prices for some of these economies. Singapore does not report an export unit value index.

†July-August average.

directly. In a survey of manufacturers taken in 1985, almost every U.S. respondent considered the ability to offer consistent quality to be of the highest importance competitively.[12] (In contrast, Japanese respondents felt the ability to offer low prices or undertake rapid design changes was a more important factor.) Given the high cost of defects, these recent quality efforts should aid both U.S. product desirability as well as relative U.S. price performance.

Underlying causes of the U.S. competitiveness improvement—analysis and outlook

Several factors underlie the substantial increase in U.S. competitiveness during the past several years. Most obviously, this improvement reflects changes in exchange market conditions resulting in the large depreciation of the U.S. dollar since 1985. Restrained wage growth has also been very important for improving the relative U.S. price position, but at the cost of slower growth in real earnings for manufacturing employees. More positive for U.S. competitiveness have been other major factors affecting U.S. price and quality. These factors include investment levels, technology efforts (spurred by research and development expenditures), industrial restructuring, and, to a more limited extent, work reorganization. It is these factors that shape how modern and efficient the production process is, as well as how technologically advanced and defect-free manufactured output becomes. And accordingly, it is these factors that determine the level of output per unit of input and the quality of the output produced. Perhaps most importantly, these factors affect the overall level of wage increase manufacturing employees can expect, a major goal of the competitiveness drive.

Significant changes in exchange market conditions, investment levels, technology efforts, industrial structure, and work organization have occurred in recent years. These changes precede improvements in price and quality competitiveness, which in turn occur well before actual purchase decisions are made and market shares determined. It is important to examine recent changes in these underlying factors to understand current competitiveness gains and to anticipate near-term competitiveness changes. Moreover, since some changes in these factors can be forecast in advance, it is helpful to analyze these factors to gauge what medium-term competitiveness changes may occur. Changes in factors other than the exchange rate merit more detailed attention. These changes are less obvious but, in a period when increasing emphasis is being placed on exchange rate stability, may become even more important in determining future competitiveness positions.

Changes in exchange market conditions

The recent depreciation of the dollar brought it back to its beginning-1980 level after an extraordinarily volatile seven-year period. This depreciation has already had some impact on U.S. demand for foreign products as well as foreign demand for U.S. goods. The overall impact of depreciation on U.S. market share, however, will not be fully realized until 1989 because of long-term contracts, purchasing arrangements, and inventories.

A broader consequence of the seven-year exchange rate period as a whole has been an increased desire by all countries for a relatively more stable exchange rate environment. Proposed policy coordination across countries may help achieve this goal. A relatively more stable exchange rate environment would mean that exchange rate movements would play a significantly smaller role in determining competitiveness position in the future.

Changes in investment

Investment levels are a critical factor underlying the productivity and quality performance of U.S manufacturing. These levels determine how fast new technologies, which improve product quality and productive capability, are brought into the manufacturing process. An increase in the amount of investment also leads to an increase in labor productivity as each laborer is provided with additional or more efficient capital equipment.

Perhaps the clearest example of the beneficial impact investment has on competitiveness comes from one section of the U.S. steel industry. The "mini-mills," which have invested in technologically advanced electrical furnaces, are both less capital intensive and more productive than standard integrated steel mills. Their widespread introduction into the steel industry in the 1970s and 1980s vastly improved the productivity record of U.S. steel manufacturers. In 1960 it took 2.9 manhours of labor to produce a ton of steel; in 1985 it took only 0.9 manhours to produce a ton of steel, with a reduced capital equipment requirement as well. In 1960 mini-mills accounted for less than 3 percent of steel production in the United States; in 1985 they accounted for roughly 20 percent.[13] Mini-mills, moreover, have also been credited with improving steel's quality record in recent years; their continuous casting production method yields a more uniform, better quality product.

U.S. gross manufacturing investment levels in general provided strong support to U.S. relative competitiveness

[12] Kasra Ferdows and others, "Manufacturers in U.S., Europe, Japan disagree over what makes a winner," *International Management*, September 1985, pp. 82-87.

[13] Ronald Barnett and Robert Crandall, *Up From the Ashes*. Brookings Institute, 1988, pp. 57-59.

throughout the 1980s. The level of U.S. real manufacturing investment to real manufacturing sales increased substantially over the last seven years from its average level during the 1970s (Table 4). In the early 1980s this increase was due to a larger downturn in sales than in investment. From 1984 on, however, the robust performance of the U.S. investment/sales ratio reflected brisk investment in the presence of a sharp upturn in sales. The U.S. performance compares favorably with developments in Japan and Germany. The average annual U.S. investment/sales ratio in the 1980s was only 0.3 percentage points behind the Japanese ratio, after having trailed it on average by 0.7 percentage points in the preceding decade. The U.S. ratio was sharply above the German ratio in the 1980s, substantially widening its 1970s lead.

Even more impressive than the increase in the U.S. investment/sales ratio was the increase in the U.S. real manufacturing investment/manufacturing employee ratio. This latter ratio, which measures the amount of new equipment available for use by production workers,[14] has a more direct bearing on total labor productivity. The U.S. ratio in the last six years has been significantly above both Japanese and German levels. Although the U.S. ratio reflects to some extent the greater need to replace an older capital stock than is the case in Japan and Germany, replacing equipment still leads to an increasing spread of new technology.

The U.S. investment/sales and investment/employee ratios showed particularly strong improvement starting in 1984. This development coincides with the particularly sharp productivity pick-up of the middle 1980s. U.S. investment levels were especially high in 1985 in order to avoid some negative tax reform effects for investment in 1986. However, the U.S. investment/sales ratios in 1986 and 1987 still remained well above the average level of the 1970s. The 1986 and 1987 investment/employee ratios remained significantly above the ratios for both the 1970s and early 1980s.

As for the future, it appears that investment will continue to have a favorable impact on U.S. productivity and competitiveness, at least in the near term. The gestational lag between investment and increased output, lasting up to several years, suggests that the relatively strong investment performance of the past few years will have a beneficial effect on competitiveness at least through 1989. Investment prospects in the immediate future imply that this beneficial effect will continue into the 1990s. Although the stock market crash in October increased uncertainty about the economic and investment outlook, the current backlog of investment orders and survey responses concerning investment plans since then suggest ongoing investment strength.[15] High expenditure levels on research and development (discussed in the next section) also imply concomitant high investment expenditure levels. Growing capacity constraints in manufacturing should act as a further investment spur. With a manufacturing capacity utilization rate of 82 percent at the end of 1987, capacity constraints are currently at their tightest level since 1979.[16]

Capital cost considerations also seem to indicate that investment will remain relatively buoyant, at least in the short run. Real long-term interest rates remain significantly below their 1982-84 peaks. These rates are also currently below the levels of the strong investment years of 1985-86. Over a longer time period, this financial situation could change, however. Investment expendi-

[14]This ratio is calculated by dividing the level of gross investment in constant 1980 prices converted into dollars at 1980 exchange rates by the number of manufacturing employees.

[15]"Plant and Equipment Expenditures," *Survey of Current Business*, vol. 67, no. 12 (December 1987), pp. 16-19. Strong growth in investment expenditure by the total U.S. business sector in 1988-I also suggests continued manufacturing investment strength.

[16]*Federal Reserve Bulletin*, monthly issues.

Table 4
Manufacturing Investment Ratios

	United States	Japan	Germany
Real manufacturing investment/real manufacturing sales			
1973-79 average	5.4	6.1	5.0*
1980-86 average	6.4	6.7	4.9
1980-83 average	6.2	6.2	4.8
1984-86 average	6.6	7.2	4.9
1986	6.3	7.4	5.1
1987	6.2		
Real manufacturing investment/manufacturing employee†			
1976-79 average	4.8	3.3	3.2
1980-86 average	6.1	4.9	3.8
1980-83 average	5.7	4.5	3.6
1984-86 average	6.7	5.6	4.1
1986	6.5	5.5	4.3
1987	6.5		

*1974-79 average.

†The calculation of this ratio is described in text footnote 14.

Sources: For German investment through 1985, Organization for Economic Cooperation and Development, *National Income Accounts, 1973-1985*, vol. 2, 1987. German investment in 1986 is based on growth in investment in the entire business sector. Deutsche Bundesbank, *Supplement to Monthly Report*, series 4, March 1988. For Japanese investment, Japan Economic Research Center, *Five Year Economic Forecast*, various years.

tures growing to keep pace with growing sales levels could put increasing pressure on borrowing costs. This increasing pressure might be eased by a falling public sector demand for borrowed funds. But if the U.S. government deficit and its resultant borrowing requirements remain high, capital cost considerations could have a restraining influence on investment in the medium term. On the other hand, manufacturing investment has generally been more responsive to changes in demand for manufactured products than to changes in borrowing costs. Consequently, improved competitiveness itself offers support for a strong investment outlook and further competitiveness gains.

Changes in technology and research and development efforts

Technology growth, supported by research and development expenditures, determines how fast new production methods and product improvements are devised, adapted, and implemented in production. Consequently, technology growth has a direct impact on productivity and quality performance. In fact, improved technology has been found to be extremely important for output growth. Analysts have estimated that technological advances, broadly defined, accounted for about two-thirds of the growth in U.S. output since 1900.[17] Technology growth has also been extremely important for quality improvements. Major quality control techniques, such as statistical process control and changes in design to eliminate quality problems before production actually begins, are the direct product of technological innovation.

The United States registered a very weak research and development performance relative to its major foreign competitors during the 1970s. The ratio of U.S. industrial research and development/manufacturing sales remained stagnant over that decade while foreign ratios grew.[18] As a result the United States lost some of its technological lead. Quality problems reflecting inferior U.S. technology arose in a number of U.S. industries, such as paper and textile machinery (see Appendix). By the end of the decade the United States was in a position where it could no longer be assured of sales based purely on a superior technological reputation.

As with U.S. manufacturing investment, however, there was a sharp improvement in U.S. technology efforts as measured by research and development expenditure in the 1980s. After the stagnation of the 1970s, the ratio of U.S. industrial research and development/manufacturing sales grew substantially throughout the 1980s (Table 5). By 1985 the U.S. ratio, at 2.4 percent, reached a level significantly above the German ratio and slightly above the Japanese ratio. In 1979, by contrast, the German ratio was higher than the U.S. ratio and the Japanese ratio about equaled that of the United States.

Some analysts have suggested, however, that increasing the *level* of research and development expenditure will not solve the U.S. technology problem. They argue that the *composition* of research and development expenditure needs to be changed, with greater resources devoted to the application of new technologies than to their discovery. In short, they contend that too much attention has been given to basic research at the expense of development, implying that many of the gains to efficient innovation have been lost.[19] The video cassette recorder is the most often cited example of products originating from U.S. research but developed for market by firms in other countries, particularly Japan. Patent evidence is also advanced to support the contention that the United States is weak on developing the products it invents. The share of U.S.

[17]Edward Shapiro, *Macroeconomic Analysis* (New York: Harcourt Brace Jovanovich, 1974), p. 401. As noted in the previous section, most of the new technology required capital investment, making investment expenditures very important.

[18]Research and development expenditures are often reported as ratios to GNP. Given the relatively large size of the U.S. service and agricultural sectors, however, reporting research and development/GNP ratios gives a downwardly biased impression of the U.S. research and development effort in manufacturing.

[19]See for instance the statement of Myron Tribus, Director, Center for Advanced Engineering Study, Massachusetts Institute of Technology, Hearings before the Subcommittee on Economic Stabilization of the House Committee on Banking, Finance and Urban Affairs, 98th Cong., 2d sess. (Washington, D.C.: GPO, March 1984), pp. 129-52; or James R. Kirk, "Easing the Way from Lab to Market Place," *Tough Challenges for R&D Management*, the Conference Board, 1987.

Table 5
Research and Development Trends

Industrial Research and Development Expenditures as a Percent of Manufacturing Sales

	United States	Japan	Germany
1979	1.51	1.49	1.67
1981	1.78	1.67	1.80
1982	2.05	1.88	1.92
1983	2.12	2.01	1.87
1984	2.17	2.02	1.98
1985	2.39	2.24	1.99
1986	2.62		
Change (percentage points):			
1970-79	−0.15	0.30	0.22
1980-85	0.88	0.75	0.32

U.S. Patents Granted to Inventors by Nationality

	1970	1979	1985
United States	47077	30079	39554
Japan	2625	5251	12746
Germany	4435	4527	6665

Source: National Science Foundation for research and development expenditure levels and patent data.

patents granted to U.S. nationals has fallen significantly since 1970 while the share granted to Japanese nationals in particular has risen sharply.[20]

Encouraging efforts have been made in the last few years to address this problem as well. Antitrust laws have been relaxed to encourage industry consortiums, such as the computer industry's Microelectronics and Computer Technology Corporation, that are geared to sharing research and encouraging the development of products based on this research. Technological parks have also sprung up to promote the interaction of industry, government, and university personnel so that basic research might give rise to more commercial innovation. There are now around 300 of these parks, up from only 100 in 1980.[21]

It is of note that at the same time the United States is moving more in the direction of applied research, Japan is moving somewhat in the reverse direction as a result of the success of its strong development effort in the 1970s. With much "catch-up" technological development already over, the Japanese government has now issued new research and development guidelines that put greater emphasis on basic research. According to the *Japan Economic Almanac*, the guidelines are based on the premise that "until now, Japan has concentrated on adapting technologies imported from the U.S. and Europe to promote its own scientific and technological innovations. But Japan must now shift from a beneficiary to a benefactor."[22]

This evidence of role reversal between basic and applied research efforts, however, must not be taken to mean that the United States and Japan are currently following the same overall technology strategy. A review of current technological investment in the United States and Japan suggests that the research and development priorities of the two countries continue to diverge. The United States has been concentrating investment efforts on computer software technology designed to speed the creation of new products, while Japan has been concentrating on computer hardware technology designed to speed the creation of new production techniques. The United States has invested much more heavily in computer-aided design (CAD) and computer-aided manufacturing (CAM) systems than has Japan. These systems greatly reduce the time it takes to develop new products. Japan, in contrast, has spent significantly more on the development of robots and flexible manufacturing systems (automated assembly systems that rapidly adjust to produce different products).[23] These systems are geared to reduce the costs of production.[24]

These differing investment patterns appear to indicate that the United States continues to put more emphasis on creating new products while Japan puts more emphasis on reducing the cost of producing and adapting existing products to meet specific consumer needs. Still, rapidly growing U.S. expenditures on computer-aided design and computer-aided manufacturing imply an increased U.S. effort to translate research into commercial products.

Aside from promoting the development of new products, rapid growth in the use of CAD/CAM systems in the United States is also very encouraging for U.S competitiveness because of the tremendous promise it holds for directly improving manufacturing's productivity and quality performance. According to the U.S. Department of Commerce, "Documented cases of productivity improvements from the implementation of CAD/CAM systems have cited output per manhour worked jumping anywhere from 5:1 to 20:1. . . . [Moreover] improvement in product quality and performance can be achieved through better design, greater machining accuracy, and reduction in human errors."[25] As noted earlier, CAD/CAM systems are ideally suited to quality control attempts to "design out" problems before products are actually manufactured. Consequently, their relatively fast growth and widespread application in the United States suggest a potential competitiveness gain that will last into the 1990s. A study by the Society of Manufacturing Engineers projected that 25 percent of all U.S. companies will employ CAD/CAM systems for product and tool design by 1990, as against 20 percent of Japanese companies and only 10 percent of the British companies.[26]

More generally, the renewed U.S. research and development efforts suggest a continuing boost to

[20]Patent comparisons have to be made with caution. The annual recorded number of patents obtained by different countries' nationals in any given country will be affected by the correlation between the date of patent application and the date other countries begin to make significant export sales to that country. Patent data also mix patents for adaptations in existing products with patents for new products.

[21]Edward Ungar, "Finding and Tapping the Sources of Innovation," in *Tough Challenges for R&D Management*.

[22]*Japan Economic Almanac 1987*, Japan Economic Journal, p. 241.

[23]In 1985 the ratio of apparent U.S. consumption of CAD/CAM systems to U.S. consumption of robotics was 11 to 2 while in Japan the ratio was 10 to 11. The Japanese definition of "robotics" includes certain categories of mechanical manipulators that the U.S. definition leaves out. Nevertheless, the discrepancy between CAD/CAM and robotics consumption in the United States is so great that robotics consumption would have to be inflated by over 500 percent to bring the U.S. ratio up to the Japanese level.

[24]Ferdows and coauthors discuss these contrasting spending patterns in "Manufacturers in U.S., Europe, Japan disagree," pp. 82-87.

[25]U.S. Department of Commerce, International Trade Administration, *A Competitive Assessment of the U.S. Computer-Aided Design and Manufacturing Systems Industry*, February 1987, p. 4.

[26]U.S. Department of Commerce, *A Competitive Assessment*, p. 45.

competitiveness over the next several years. Since the gestational lag between expenditure on research and development and the initial returns on that expenditure is about two years, the strong U.S. showing in research and development through 1986 can be expected to aid competitiveness for some time. Moreover, research and development expenditure is likely to remain high, although an easing of competitiveness pressures may limit its growth. A survey of research and development managers taken in early 1988 indicated 1988 research and development/sales ratios were expected to remain at 1987 levels, which in turn matched 1986 levels.[27] Equally important, the survey showed that top manufacturing management's interest in research and development has remained strong.

On a financing level, survey results indicate that strong profit growth generally supports high research and development expenditure levels.[28] U.S. manufacturing profit rates are widely expected to continue rising into 1989. Consequently, financial conditions also suggest that research and development efforts may continue to boost U.S. competitiveness into the 1990s.

Changes in industrial structure

Along with undertaking stronger efforts in investment and research and development in the 1980s, U.S. manufacturers reacted to competitiveness problems by sharply escalating the scale of industrial restructuring. In its broadest definition, industrial restructuring includes both real consolidation associated with layoffs and other cost reduction efforts and financial diversification associated with mergers and acquisitions. Increased use was made of both practices during the last seven years.

Job layoffs and plant closings generally have a positive effect on productivity and, therefore, on competitiveness measured in market share terms, albeit at a high cost to U.S. manufacturing employees. The positive impact of job layoffs and plant closings on productivity is fairly direct. Layoffs and closings cut the number of excess workers and the level of underutilized capital, thereby improving the output/employee and output/capital stock ratios. Cuts generally affect the less experienced employees and the less efficient plants, further boosting productivity. Of course, some of the gains to productivity are offset by the loss of specific task-related skills when workers are forced into temporary or permanent changes in jobs. Nevertheless, the net impact of workforce and plant trimmings on productivity is, at least initially, positive.

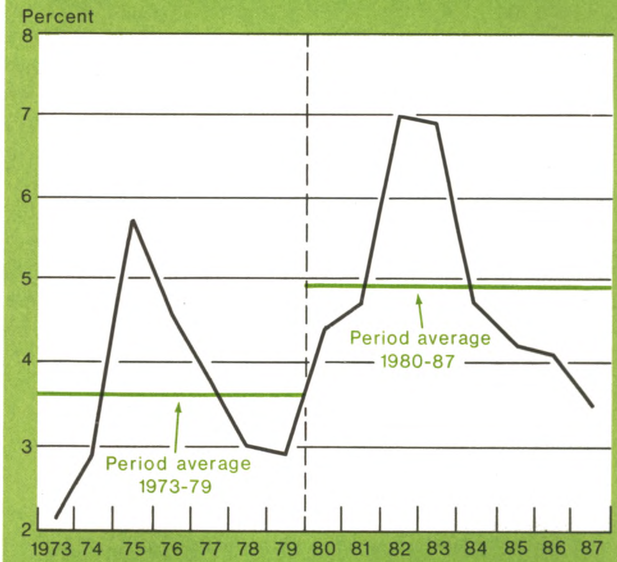
Job losses and plant closings in the 1980s increased sharply from their levels in the 1970s. Job losers in all industries averaged about 5 percent of the employed labor force, or 4.6 million people, during the 1980-87 period, in contrast to only 3.5 percent of the labor force, or 2.9 million people, during the 1973-79 period (Chart 4). While a portion of the high 1980s average represents cyclical adjustment to the severe recession at the start of the decade, at least a portion seems to represent a more structural change toward workforce trimming, itself in part due to the substitution of machines for jobs. In fact, even after the 1980s recovery was firmly established, layoff rates remained relatively high, with the average 1984-87 layoff rate substantially greater than nonrecessionary averages for the 1970s. About one-half of job losers were from manufacturing industries.

As for plant closings, the dollar value of retirements of manufacturers' buildings more than doubled from $18.3 million in 1979 to $41.7 billion in 1985. Some of these "retirements" reflect ownership changes rather than actual plant closings. Dollar values have also risen

Chart 5

U.S. Job Losses

As a Percentage of Total Employed Labor Force



[27]"Industrial Research Institutes' Annual Research and Development Trends Study," *Research-Technology Management*, January-February 1988, pp. 30-33. Survey results from Battelle show similar research and development expenditure plans. Battelle's survey indicates that private research and development expenditure is expected to grow 4 to 5 percent in 1988. This is about the rate by which manufacturing sales are expected to grow. The Battelle survey is cited in *Forbes*, February 8, 1988, p. 29.

[28]"Accounting for Research and Development Expenditure," *Research-Technology Management*, January-February 1988, p. 40.

because of inflation. Nevertheless, the numbers are evidence of significant plant restructuring activity in the 1980s.

The relatively high rate of layoff and plant closing activity during the last seven years will, however, likely be self-limiting in the near future. The extent of layoffs and closings since 1980 suggests that a major proportion of inefficient production units have already been removed, reducing the productivity gains from further layoff and closing activity. Strong sales growth, moreover, has left capacity utilization rates high in a number of manufacturing industries. Increased employment and investment rather than layoffs and closings appear likely in many areas.

Merger and acquisition activity, the other major form of industrial restructuring, has also had some impact on recent U.S. price competitiveness, although the magnitude of its effect has been debated. In principle, mergers and acquisitions can improve productivity and profitability by encouraging units in the newly formed organizations to cooperate and to share knowledge and managerial skills. Despite the positive effects of integration, however, mergers and acquisitions change management structures and work relations in ways that may be harmful, at least initially, to workplace industrial relations. Evidence to date suggests that merger and acquisition activity has improved productivity performance in some areas but not uniformly throughout manufacturing.[29]

At an industry level some positive association has been found between the intensity of merger and acquisition activity and industrial productivity growth. Specifically, the high merger activity levels in mining, railroad transportation, and electrical equipment manufacturing were associated with rapid productivity growth in these same industries over the 1980-85 period.[30] On the other hand, a recent study of the merger and acquisition records of the 33 largest diversified U.S. companies over the period 1950-86 shows that, on average, the acquiring companies had eventually divested themselves of greater than 50 percent of their acquisitions in new industries and greater than 60 percent of their acquisitions in new fields because of disappointing profit outturns.[31] Given these mixed results, it is unclear what effect future merger and acquisition activity will have on U.S. competitiveness.

Changes in work organization

Major changes in work organization have taken place in the United States over the last seven years. Many of these changes have been inspired by the perceived success of Japanese work organization. The Japanese model features lifetime employment, widespread profit sharing, teamwork, and the creation of quality and management circles in which employees share ideas for improving both the product and the production process. Among recent U.S. changes are increased use of quality circles, profit sharing as a means of remuneration, increased adoption of work teams with joint responsibility for production, reduction of work rules assigning individual tasks, and reduction in the number of job classifications and titles at the workplace.

Some of these changes have been fairly broadly adopted. For example, employee involvement programs are fast becoming an important component of U.S. human resource management strategy. A 1982 study by the New York Stock Exchange showed that 52 percent of large firms (with greater than 10,000 workers) had a formal quality circle program. Many of these programs have been implemented in smaller work establishments as well.[32]

Another Japanese-inspired concept recently adopted fairly widely in the U.S. workplace is the use of profit-sharing arrangements as a form of employee remuneration. In 1986 one-third of all major collective bargaining agreements included a lump sum or profit-sharing clause, up from only 1 percent in the late 1970s. Although many changes arose from concessionary bargaining during the recession of the early 1980s, the use of lump sum and profit-sharing arrangements and the reduction of work rules have been occurring with much greater frequency since 1984 (Chart 6) than during the recessionary years.[33]

It is still relatively early to judge the impact of these work organization changes. Current evidence suggests that, like mergers and acquisitions, the new practices have had substantial payoffs in some but not all instances. At the General Motors, Toyota, and United Auto Workers joint venture New United Motors Manufacturing Incorporated (NUMMI) Plant, where many new work organization methods have been implemented, reported productivity is an astounding 50 percent higher

[29]See for example, the analysis offered by Michael Porter, "From Competitive Advantage to Corporate Strategy," *Harvard Business Review*, May-June 1987, pp. 43-59.

[30]John Paulus and Robert Gay, "U.S. Mergers are Helping Productivity," *Challenge*, May-June, 1987, pp. 54-57.

[31]Porter, "From Competitive Advantage," pp. 43-59.

[32]For the New York Stock Exchange Survey of large establishments, see William C. Fruend and Eugene Epstein, *People and Productivity*, Dow-Jones-Irwin, 1984. For a survey of somewhat smaller establishments (greater than 1,000 workers), see Sirota and Alper Associates, *The National Survey of Employee Attitudes*, 1985.

[33]For a discussion of the path of employee concessions in the 1980s, see Linda Bell and Elizabeth Hall, "Concessionary Bargaining in the 1980s," unpublished paper, 1987.

than before changes were adopted.[34] However, within the U.S. automotive industry, with the exception of U.S.-Japanese joint ventures, the adoption of Japanese-style production has apparently been less successful to date.[35] Similar results are found in a study of the productivity effects of employee stock ownership plans.[36] Some success has been reported in achieving quality improvements from changes in work structure. Placing workers on design teams with engineers has proved to be a major factor in improving the quality performance of electronic components producers.

Overall, the impact of work organization changes has been mixed. What does appear encouraging for U.S. competitiveness in the future is the fairly strong willingness of U.S. labor and employers to make adjustments to work organization in an attempt to achieve productivity and quality improvements. There has been a strong growth trend in profit-sharing and work-rule reduction plans in the 1980s. Both this growth trend and the receptiveness to new work arrangements suggest that support for productivity growth may continue to come from the work organization area.

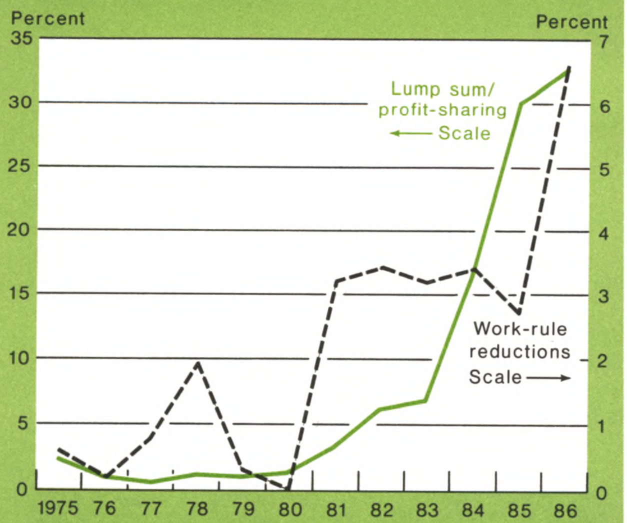
[34]The NUMMI plant guarantees job security to workers. It also places them in work teams and trains them for multiple task assignments. The job classification system has been reduced from nearly two hundred original occupational titles to just three. The major change in physical plant has been the introduction of an in-plant stamping section. This change was adopted in order to use the Japanese Just-in-Time production system, in which output goals are determined by input needs at subsequent production stations.

[35]Haruo Shimado and John Paul MacDuffie, "Industrial Relations and 'Human Ware': Japanese Investments in Automobile Manufacturing in the United States," National Bureau of Economic Research Conference Paper, December 1986.

[36]Steven Bloom, "Employee Stock Ownership and Firm Performance," Ph.D. dissertation, Harvard University, 1985.

Chart 6

Share of Contracts with Lump Sum/Profit-Sharing Arrangements or Work-Rule Reductions*



*Number of contracts specifying either condition as a share of all major collective bargaining agreements negotiated in that year.

Conclusions

U.S. manufacturing has clearly became more competitive in recent years. This achievement was the result of sharp dollar depreciation, wage restraint, and strong improvements in U.S. productivity and quality performances. At a more fundamental level, these improvements reflect increased investment levels, technology promoted by research and development efforts, industrial restructuring, and work reorganization.

In the near future, the competitive position of the U.S. manufacturing sector will most likely improve further. The full trade benefits of recent dollar depreciation will not be felt until the end of 1989. Moreover, changes in underlying productivity and quality determinants that have already occurred suggest further strong productivity growth and ongoing quality improvement. Specifically, typical gestational lags between expenditure and return imply that the vigorous investment and research and development efforts undertaken in manufacturing in recent years will promote productivity and quality advances at least through the end of the decade. Recent work organization changes and merger activity should also promote some productivity and quality improvement, although benefits will be much more sporadic across industries and firms.

Beyond the next year or so, ongoing trends in the key determinants suggest continued competitiveness improvement. Planned expenditures for investment and research and development remain strong, with those for 1988 matching their high 1987 levels. The search for new work organization and management techniques is also steadily progressing. Over time these positive trends should lead to greater U.S. competitiveness, with a concomitant decline in the U.S. foreign trade deficit and improved job opportunities and compensation for manufacturing employees.

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Appendix: Industry-specific Quality Comparisons

International quality comparisons are available for 11 broad industry groupings. These comparisons vary in depth of coverage both in regard to change over time and detail of analysis. Summaries of the comparisons are presented here. On the basis of these comparisons, we have classified U.S. industries as having a "quality problem" or "no quality problem." Two of the industries are classified as having "quality improvement." The quality comparisons for these two industries suggest that U.S. products had been found inferior but had improved over time. Conclusions drawn from the 11 quality comparisons are presented in the text.

Automobiles
(1986 shipments of $111 billion)—quality problem

Consumer Reports ratings for selected U.S. and Japanese automobiles for 1970, 1980, and 1985 suggest that U.S. cars had on average more repair problems than the Japanese models. (Model lines selected for comparison were model lines that were rated in all three years.)

Business Week also reported that new 1987 U.S. cars had more after-sale problems than Japanese and German imports, although fewer than Swedish imports. For every 100 new U.S. cars sold, 175 problems were reported up to 90 days after purchase; this figure contrasts with 129 problems per 100 Japanese cars, 152 problems per 100 German cars, and 200 problems per 100 Swedish cars.*

Percentage of Categories in Which Autos Had a Better or Worse than Average Repair Record

	1970		1980		1985	
	Better than Average	Worse than Average	Better than Average	Worse than Average	Better than Average	Worse than Average
Chevrolet Camaro	35	12	0	29	0	82
Ford Thunderbird	7	47	20	47	27	7
Pontiac Grand Prix	13	27	0	33	7	27
Toyota Corolla	35	18	94	0	65	0
Datsun 510/Maxima	53	18	76	6	24	18

Note: Categories are air conditioning, exterior body, body hardware, body integrity, brakes, clutch, drive line, electrical chassis, engine cooling, engine mechanics, exhaust, fuel system, ignition system, steering suspension, transmission. In some instances, models could not be rated for all categories.

Source: Derived from *Consumer Reports*, new car issue, various years.

Paper and allied products
(1986 shipments of $103 billion)—quality problem

A Dow Chemical Company report found that quality standards within the U.S. paper industry were substantially inferior to those in European paper industries. The report found that the U.S. industry suffered from insufficient investment in research and development and a lack of interaction between product suppliers and consumers. The rapid development of new products in Europe eroded the market share for U.S. products. European product development was supported by a cooperative relationship between producers, distributors, publishers, and others involved in the use of paper products. This European network fostered better market feedback, which in turn encouraged product innovation and improved product performance. An industry executive observed, "The pendulum has swung and many U.S. pulp and paper companies are now paying for a lack of foresight."†

Further, the industry's quality standards for newsprint have suffered in comparison with those of Japanese newsprint producers. The *Japan Economic Almanac 1987* reported that Japanese newspaper companies found Japanese newsprint quality substantially superior to U.S. quality.‡

Steel (1986 shipments of $46 billion)
—quality improvement

Ford Motor Company reported that during 1979-81 its rejection rate for steel supplied by U.S. companies was about 8 to 9 percent, in contrast to a 3 percent rejection rate for European steel suppliers and a 1.5 percent rejection rate for Japanese steel suppliers. By 1985, however, the rejection rate for U.S. steel suppliers had fallen to less than 2 percent, as against 3 percent for European suppliers and 2.5 percent for Japanese sup-

Business Week, June 8, 1987.

†*Pulp and Paper*, April 1987, pp. 54-62.

‡*Japan Economic Almanac*, 1987, p. 169.

Appendix: Industry-specific Quality Comparisons *(continued)*

pliers. Ford Motor Company also reported a "dramatic" improvement in delivery time from U.S. steel suppliers over this time period.§

Electronic parts (1986 shipments of $40 billion) —quality improvement

Xerox Corporation reported that in 1984 U.S. electronic parts supplied to Xerox were roughly five times as likely to fail as parts supplied to Fuji Xerox Company Ltd. of Tokyo (Xerox's joint venture with Fuji Photo Film Company Ltd.). By 1986, however, U.S. parts supplied to Xerox had attained quality parity with Japanese parts supplied to Fuji Xerox.‖

Pharmaceuticals
(1986 shipments of $33 billion)—no quality problem

The International Trade Administration underscored "the competitive strength of U.S. pharmaceutical companies" and attributed this strength to "the quality and reputation of the pharmaceuticals produced by those companies."¶

Construction equipment
(1986 shipments of $14 billion)—no quality problem

The International Trade Administration concluded that "technical superiority, high quality products, and superior service and dealership networks" characterized the U.S. construction equipment industry in comparison to foreign competitors.**

Consumer electronics
(1986 shipments of $8 billion)—no quality problem

Consumer Reports ratings for U.S. and Japanese microwave ovens, stereo speakers, and 19-inch televisions in 1975, 1981-82, and 1985-86 suggest that U.S. and Japanese quality records were about even.

Machine tools
(1986 shipments of $5 billion)—no quality problem

An International Trade Commission survey of U.S. purchasers of machine tools suggested that standardized U.S.-made machine tools suffered in quality comparison with standardized foreign-made machine tools, but it rated U.S. quality higher for specialized machine tools. "Purchasers responded [in the survey] that overall, in their opinion, foreign-made machine tools are better designed than U.S.-made machine tools, have higher productivity, and require less maintenance. U.S.-made machine tools were rated as slightly more durable than foreign-made products. U.S. machine tool builders have generally concentrated on production of specialized types of machine tools for the machinery and fabricated-metal products industries, as well as the transportation industry. As a result, purchasers in these industries have indicated that U.S.-made machine tools are superior to foreign-made machine tools."††

Electric power generating equipment
(1986 shipments of $4 billion)—no quality problem

A comparison of the performance of U.S.-made and

§Paul R. O'Hara, "Assuring Steel's Competitiveness for the Automotive Industry," in *Steel Comments*, American Iron and Steel Institute, February 28, 1986.

‖*Electronic Business*, January 15, 1987.

¶U.S. Department of Commerce, International Trade Administration, "A Competitive Assessment of the U.S. Pharmaceutical Industry," December 1984, p. 86.

**U.S. Department of Commerce, International Trade Administration, "A Competitive Assessment of the U.S. Construction Equipment Industry," February 1985, p. 73.

††U.S. International Trade Commission, "Competitive Assessment of the U.S. Metalworking Machine Tool Industry," September 1983, p. 105.

Consumer Electronics
Percentage of Product Characteristics in Which Products Had an Average or Better Rating
(Number of Products Rated in Each Category in Parentheses)

Product	1975	1981-82	1985-86
Microwave ovens			
Number of characteristics rated per product	—	5	2
U.S. product ratings	—	60 (1)	79 (5)
Japanese product ratings	—	47 (3)	100 (7)
Stereo speakers			
Number of characteristics rated per product	2	3	2
U.S. product ratings	42 (6)	62 (9)	50 (8)
Japanese product ratings	100 (2)	25 (4)	50 (4)
Televisions			
Number of characteristics rated per product	12	9	13
U.S. product ratings	81 (4)	75 (4)	88 (2)
Japanese product ratings	75 (2)	68 (7)	84 (8)

Note: Both the products and the characteristics upon which the evaluations are based varied across the sample periods. No correction for these factors is made in the reported percentages.
Source: Derived from *Consumer Reports Buying Guide* issues for 1975, 1982, and 1987.

Appendix: Industry-specific Quality Comparisons *(continued)*

foreign-made electric power generating equipment used by the Tennessee Valley Authority shows that U.S.-made equipment is superior. U.S.-made equipment significantly outranked foreign-made equipment in terms of both the availability factor (the ratio of time equipment is able to produce electricity to the total time in a given period) and the capacity factor (the ratio of power actually generated by equipment to the power the equipment would generate if operating at full capacity for a given time period). The North American Electric Reliability Council reported similar results from statistical data collected from all U.S. electric utilities.‡‡

Textile machinery
(1986 shipments of $1 billion)—quality problem

The International Trade Administration found a quality problem with U.S.-made machines. "The primary factor affecting the competitiveness of U.S. textile machinery producers in both export markets and in the domestic market is the technology gap between foreign and U.S.-produced equipment. Although U.S. textile machinery producers have enhanced the level of advanced technology built into their yarn preparation and dyeing/finished equipment in recent years, they have not kept pace with foreign technological advances in the weaving and spinning sectors....This assumes great importance since the weaving and spinning sectors of the industry have generally accounted for the largest dollar portion of equipment sales....[U.S.] domestic producers are also unable to match the international marketing networks developed by foreign textile machinery manufacturers over the past 15 to 20 years."§§

General aviation aircraft
(1986 shipments of $1 billion)—no quality problem

The International Trade Administration found that U.S.-built aircraft rate high in relative quality. "The vast amount of production experience and the technological quality embodied in U.S. airplanes help to keep [U.S.] domestic manufacturers in the lead."// //

Note: A consumer appliance quality comparison has been excluded because international trade in consumer appliances is very small (given the large bulk of most appliances). David Garvin did provide evidence in a 1983 study ("Quality on the Line," *Harvard Business Review*, September-October 1983, pp. 65-75) that the quality of U.S. room air conditioners was inferior to the quality of Japanese room air conditioners. *Business Week*, however, found significant improvement in the quality of U.S. consumer appliances in the 1983 to 1986 period ("The Push for Quality," *Business Week*, June 8, 1987, p. 140).

‡‡U.S. Department of Commerce, International Trade Association, "A Competitive Assessment of the U.S. Electric Power Generating Equipment Industry," October 1985, pp. 37-38.

§§U.S. Department of Commerce, International Trade Administration, "A Competitive Assessment of the U.S. Textile Machinery Industry," January 1987, pp. 31-32.

// //U.S. Department of Commerce, International Trade Administration, "A Competitive Assessment of the U.S. General Aviation Aircraft Industry," June 1986, p. xvii.