Final Draft

AN ASSESSMENT OF U.S. COMPETITIVENESS IN HIGH-TECHNOLOGY INDUSTRIES

A Study Prepared for the
Working Group on High-Technology
Industries
of the
CABINET COUNCIL ON COMMERCE
AND TRADE

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Contents

I. Introduction

For many years after World War II, the United States was the world leader in industrial technology. As other countries recovered from the war and as international trade intensified, the world economy expanded and became more integrated. By the 1960s, the economies of the advanced developed countries had reached the point where they displaced many types of American products in world markets. They still, however, needed American high-technology goods and expertise. Thus, the composition of American exports shifted toward capital goods and services embodying significant investments in research and development.

Recently, however, the research and development capabilities and activities of other advanced economies have increased and broadened. The United States has lost and may continue to lose competitiveness in high-technology industries. Broad trade patterns and industry-specific data support this view. The technological sophistication of foreign firms now rivals or surpasses that of the United States in segments of critical technologies, such as fiber optics, computer componentry, antibiotics, biotechnology, and semiconductors.

In the past, the United States has principally competed in the high-technology arena on the strength of the uniqueness of its technological expertise. As other countries have risen to the U.S. level of performance, other factors, such as price and quality, have become more critical.

These changes largely reflect the closing of the technological gap between the United States and other major industrialized societies. This narrowing was inevitable because of their relatively modest base. It is less costly to catch up than it is to innovate and develop new markets. But overlaying these broad evolutionary trends are factors that have accelerated the U.S. decline in competitiveness. Other countries have been willing to make sacrifices to increase their competitiveness in high-technology industries.

This report presents the results of an objective analysis of how the research-intensive industries of the United States have performed relative to those of Japan, France, and West Germany. The comparison is limited to these countries to simplify the presentation and because they are the principal U.S. competitors in high technology. In certain industries, other countries may be as important.

The report discusses the importance of high-technology industries to the United States, presents the evidence of the eroding U.S.

position, and assesses some of the causes of this erosion. These causes include more favorable general economic conditions abroad, greater relative growth in total research and development effort, ready access to low-cost investment capital, a relative increase in highly trained scientific and technical personnel, and industrial policies that seek to promote the growth of high-technology industries. The transfer of U.S. technology to other countries has also contributed to the decline in U.S. competitiveness, but it has not been a principal contributor.

A declining U.S. relative position in high technology has implications for the U.S. standard of living and the ability of U.S. firms to continue to conduct R&D at the current rate. The underlying premise is that the industrial composition of the U.S. economy matters. These research-intensive sectors provide the United States with a dynamic industrial core and, in the past, a strong international competitive position. Because these industries are essential to both U.S. productivity and national security, their continued health and vitality has a significance far greater than their seemingly small scale may indicate.

The high-technology segment of the U.S. economy is a collection of nine industries with an important common characteristic: an exceptionally high degree of continuing investment in research and development. In the second and third sections, to identify the relative performance of these industries and to compare overall U.S. trade performance against Japan, Germany, and France, these nine industries are combined into a single "high-technology sector." Appendices A and B discuss the methods used to identify high-technology sectors and present data that are based on the alternative definitions.

Further, to illustrate the changing relative U.S. position in these high-technology industries, this report presents examples of where major shifts are likely to occur. More detailed discussions on each example are presented in Appendix C. These illustrations, drawn from a cross-section of high-technology industries, form the basis for the conclusion that the relative U.S. position in high technology may continue to weaken unless its decline can be quickly reversed.

II. The Importance of High-Technology Industries to the United States

High-technology industries are important both because of their direct contributions to the growth of the American economy and to national security and because of their indirect contributions to the competitiveness of other sectors.

- Nine of the ten fastest growing U.S. industries in the 1980s are high-technology industries.
- Over two-thirds of all defense hardware purchases originate in the high-technology sector.
- Over three-quarters of all industrial research and development effort goes into creating new products that in turn benefit the growth of productivity of the sectors that consume them.

The industries comprising the high-technology sector of the U.S. economy have been identified as:

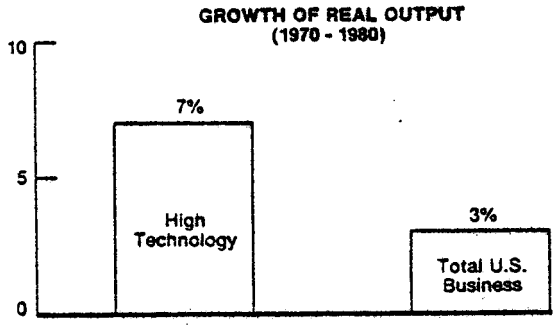
- communications equipment;
- electronic components;
- aerospace;
- computers and office equipment;
- drugs and medicines;
- industrial chemicals;
- professional and scientific instruments;
- engines, turbines, and parts; and
- plastic materials and synthetic resins.

These industries are grouped together into a single entity for the comparisons in this chapter.

The importance of high-technology industries to the U.S. economy is reflected by their disproportionate contribution to research, their high rate of productivity and growth, and their overall favorable balance of trade. These benefits have a ripple effect throughout the economy as other industries absorb the new technologies and create new jobs.

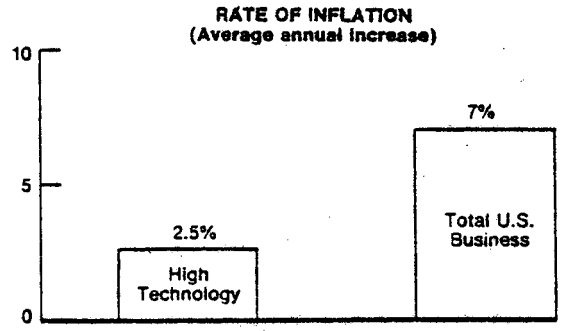
Although they represented only 13 percent of the value of product shipments in 1980 and only 5 percent of total employment, their research expenditures accounted for more than 60 percentof total U.S. private industrial R&D, and they employed more than 25 percent of total scientific and technical manpower.

Figure 2.1



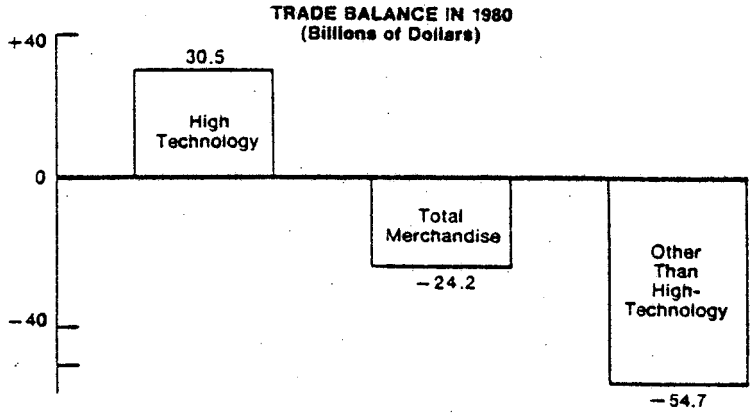
During the past decade, their rate of growth of real output was more than twice that of the growth rate of total U.S. industrial real output.

Figure 2.2



Their 1970-80 average rate of increase in prices was one-third that of the country's overall average inflation rate.

Figure 2.3

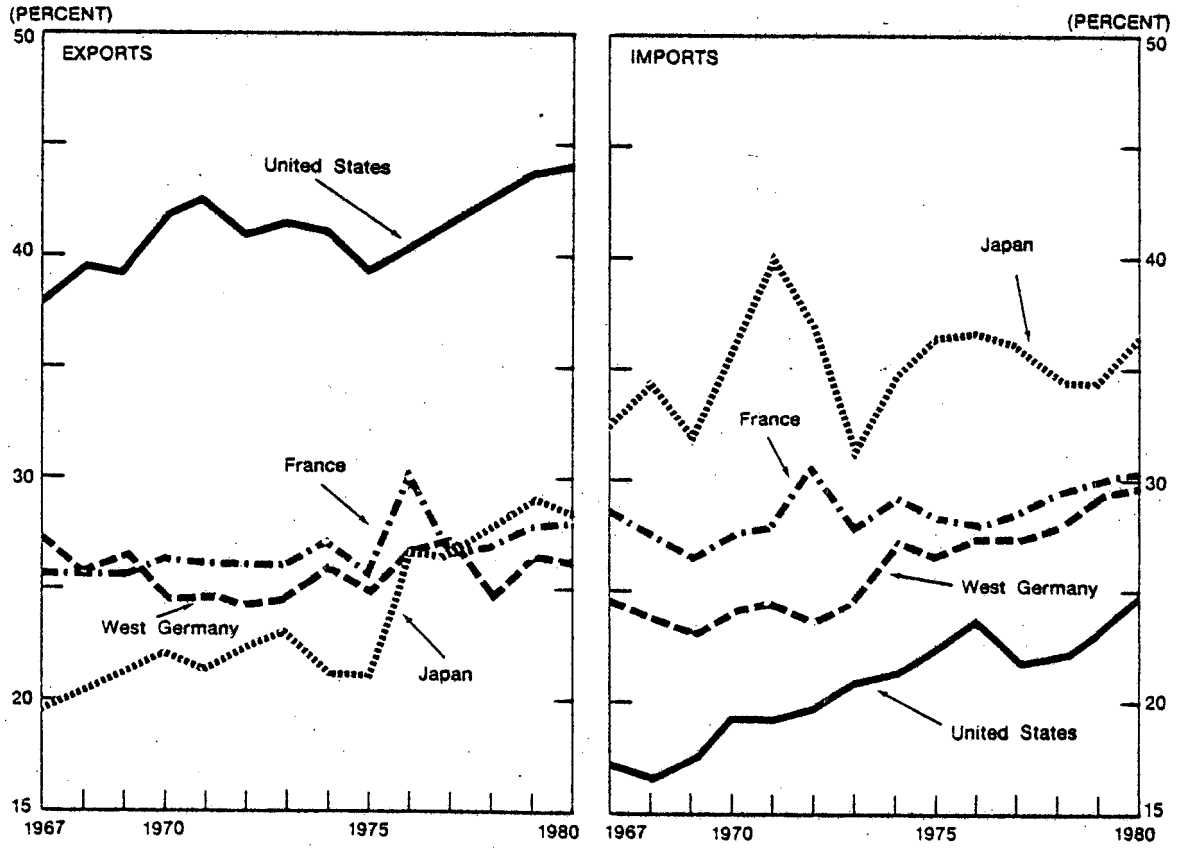


In 1980, high-technology products had a favorable trade balance of $31 billion, in contrast to all other manufactured goods, which had a trade deficit exceeding $50 billion.

The United States is unique in the important component that high-technology goods represent in its exports. Between 1967 and 1980, the proportion represented by high technology has grown from less than 40 percent of total manufactures to about 44 percent. It is also important to note that the high-technology component of U.S. manufactures imports has steadily climbed--from about 16 percent to 25 percent. Thus, overall U.S. manufactures trade is increasingly concentrated in high technology.

Figure 2.4

High-Technology Goods Comprise a Large and Growing Share of U.S. Manufactures Imports and Exports

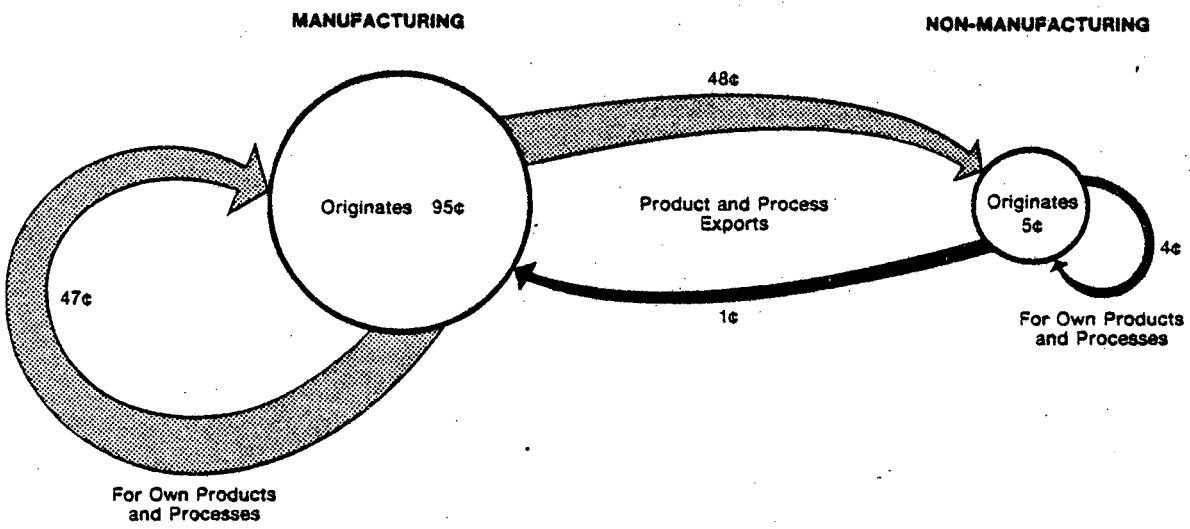


Source: DOC/ITA

The service sector receives half of the benefits resulting from the R&D performed within the manufacturing sector, especially the high-technology component.

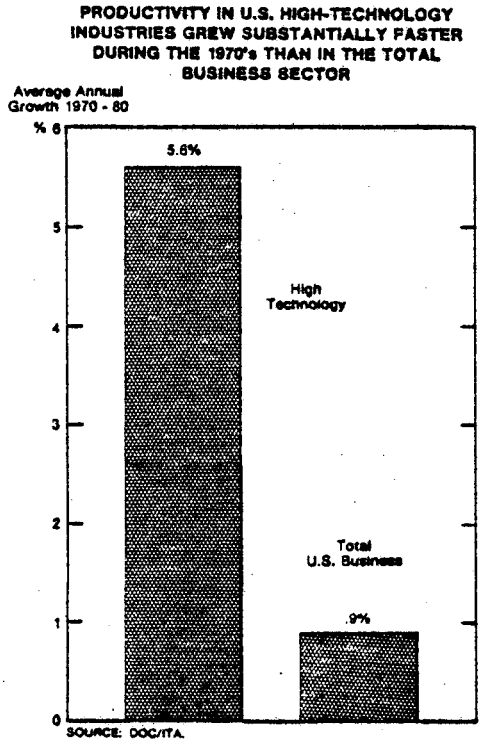
Figure 2.5

For Every Dollar of R&D Performed, the Service Sector Receives Half the Benefit



Source: F. M. Scherer; "Research and Development, Patenting, and the Micro-Structure of Productivity Growth;" Report to NSF, June 1981.

Figure 2.6

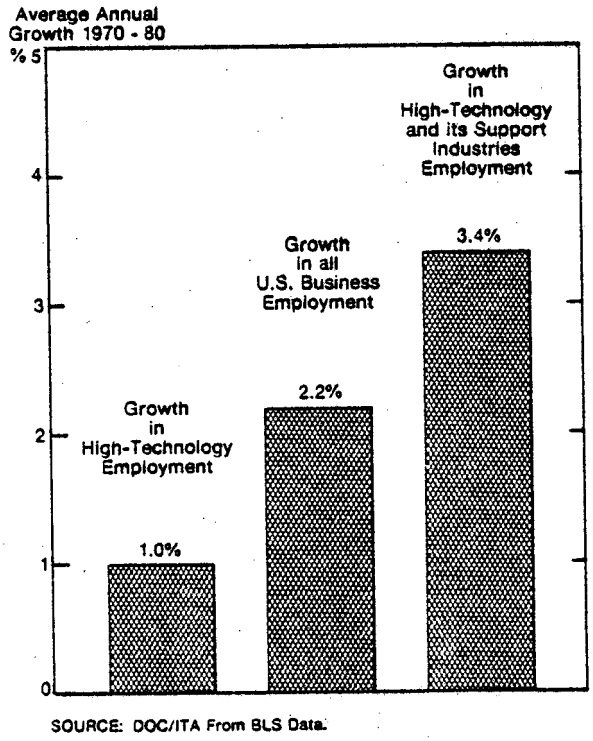


During the 1970s the productivity of high-technology industries has grown, on average, six times faster than average business productivity.

Because of this high productivity rate, however, the U.S. high-technology sector lags behind the overall performance of the business sector in creating new jobs. But in the industries supporting high technology, employment expanded over 50 percent faster than the overall growth rate of employment between 1970 and 1980.

Figure 2.7

OUTPUT GROWTH IN HIGH-TECHNOLOGY INDUSTRIES CAUSED RAPID EMPLOYMENT GROWTH IN SUPPORT INDUSTRIES



SOURCE: DOC/ITA From BLS Data.

For every job created within the U.S. high-technology sector, eight jobs are created in sectors that supply it. This job multiplier does not include the jobs created in downstream industries whose enhanced competitiveness and productivity results from the application of high-technology products and related services.

III. Evidence of Declining U.S. Competitiveness in High-Technology Industries

A range of indicators can be used to gauge the relative competitiveness of U.S. high-technology industries. Regardless of whether the indicators used are broadly defined, such as balance of trade figures, or narrowly defined, such as industry-specific assessments of relative technological capabilities, other developed countries have made significant strides in narrowing the overall U.S. lead in industrial technology. These changes mark a new international competitive environment for U.S. high-technology industries.

BROAD TRADE INDICATORS SHOW A CHANGING U.S. POSITION*

Technology-intensive products have traditionally been a source of strength in the U.S. trade balance. For decades, the United States was unique among developed countries in the importance of high-technology exports to its overall trade pattern. Yet indicators of competitiveness show a broadly deteriorating U.S. position through the early 1970s and a more complex changing picture since 1973.

Japan, on the other hand, is shown to be rapidly gaining in competitiveness in these products by almost any measure used. The change in the German and French competitive positions is ambiguous, with gains shown by some indicators, and no change or losses shown by others.

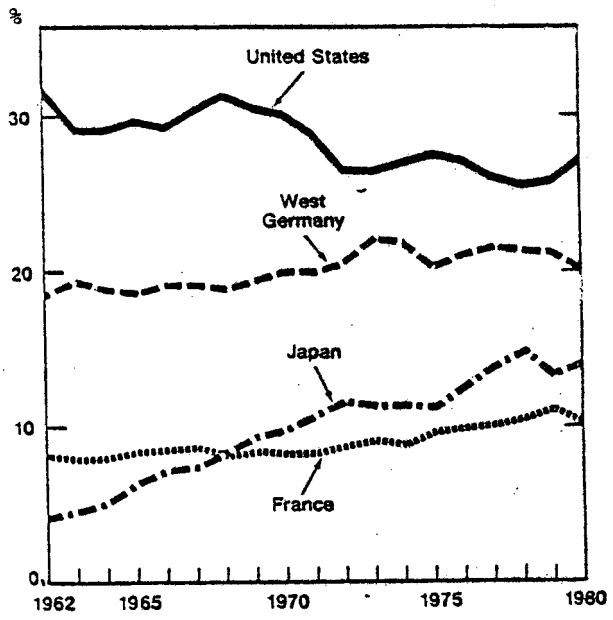
Relative Changes in Export Market Share

The most commonly used indicator of international competitiveness is the export market share a country's products maintain over time.

*See Appendix A for a definition of high technology. For the purposes of this report, the definition used excludes the automobile and consumer electronics industries. The decline in U.S. competitiveness would be more pronounced if these sectors were included. The definition used in this section is designated as DOC2, excluding radios and television receivers.

Figure 3.1

Percent of Industrial Country High-Technology Imports



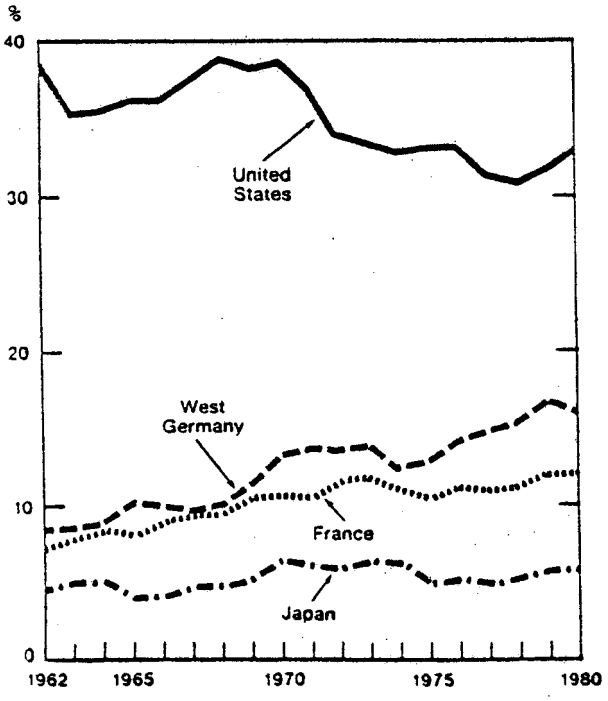
Source: DOC/ITA from UN Series D Trade Data.

The industrial countries are: Austria, Belgium, Canada, Denmark, France, Italy, Japan, Luxembourg, Netherlands, Norway, Sweden, Switzerland, United Kingdom, United States, and West Germany.

From 1962 to 1980, Japan's share of world exports of high-technology products increased from 4 percent to 14 percent, while the German and French shares increased only marginally. The U.S. share declined from 32 percent in 1962 to 27 percent by 1974 and has not exhibited any decisive trend since then.

Figure 3.2

Share of Third-Country High-Technology Markets



Source: DOC/ITA from UN Series D Trade Data.

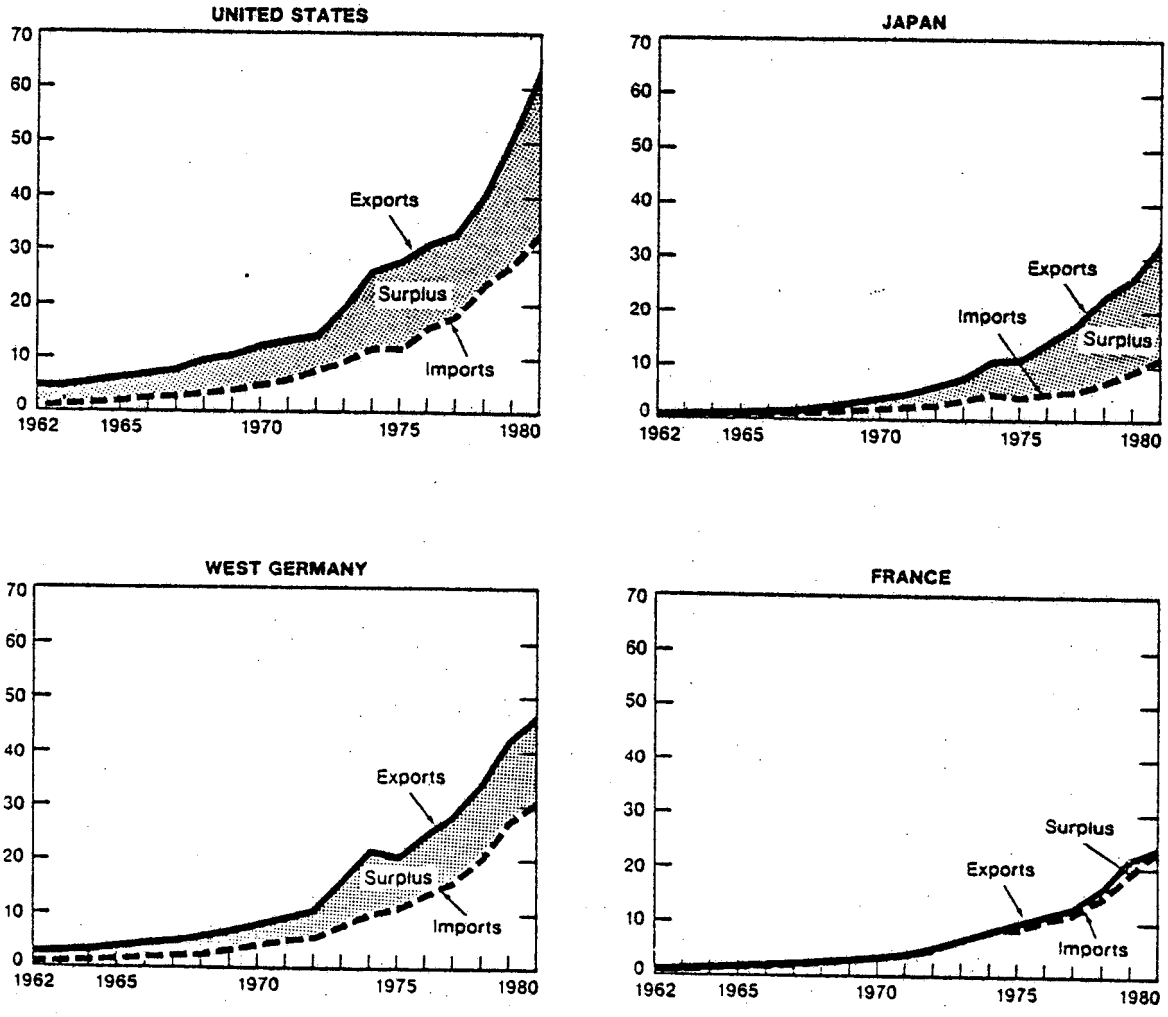
In third-country markets during the same period, the U.S. share declined from 38 percent to 33 percent; Japan's share increased only slightly, from 5 percent to 6 percent; and Germany's and France's shares increased markedly, going from 9 percent to 16 percent and from 7 percent to 12 percent, respectively.

Relative Changes in the Balance of Trade

The U.S. trade balance in high-technology products increased from 1962 through 1980. However, comparing this growth with that of the Japanese and German trade balances reveals evidence of a decline in competitiveness. The U.S. balance grew 12 percent annually, while Japan's balance increased by 35 percent, and West Germany's by 13 percent. France's 4 percent annual growth rate was the slowest.

Figure 3.3

Japanese and German Trade Balances Increased Faster than U.S. Balance from 1962 to 1980
(Billions of U.S. Dollars)



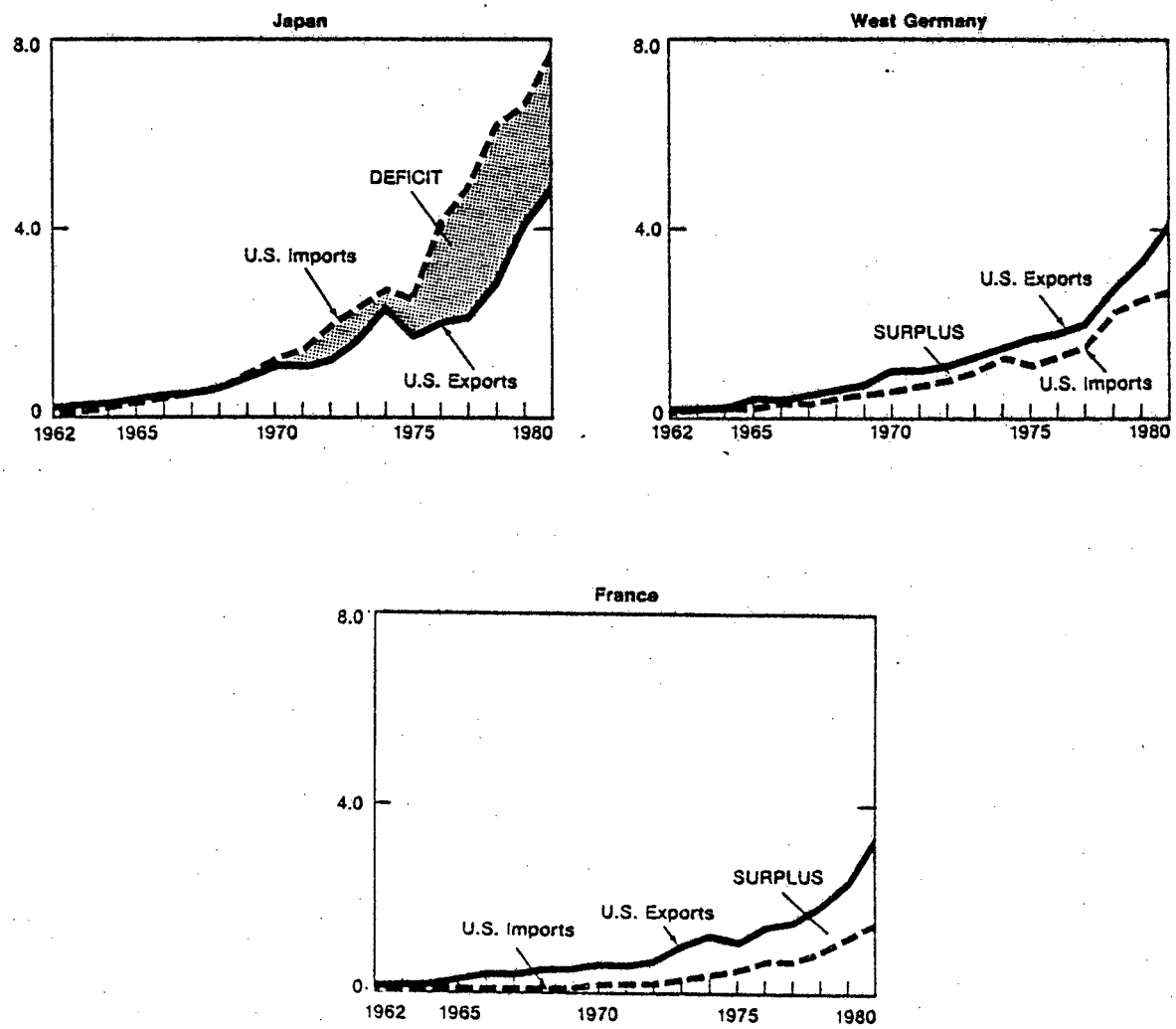
*Note: The definition of high technology used here is the DOC2 definition excluding radio and TV receivers.

Source: ITA/DOC from U.N. Series D Trade Data.

The bilateral trade balances of the United States in high-technology products with its three principal competitors illustrate a loss of competitiveness with Japan, with a deficit beginning in 1968 and continuing through 1980. The U.S. balances with France and Germany remained in surplus throughout the same period.

Figure 3.4

Since 1968, the U.S. Bilateral Trade Balance in High Technology with Japan Has Shown a Deficit
(Billions of U.S. Dollars)



'Note: The definition of high technology products used is the DOC2 definition excluding radio and TV receivers.

Source: DOC/ITA from UN Series D Trade Data.

INDUSTRY-SPECIFIC CASES ALSO INDICATE A DECLINING U.S. POSITION

The following brief assessments show the changing U.S. competitive position in several important high-technology sectors. In all cases the U.S. lead has declined or become vulnerable. More detailed studies and additional sources appear in Appendix C.

Pharmaceuticals

Over the past twenty years, the American domination of world pharmaceutical markets has steadily declined. Competitive advantage depends on the manufacturer's ability to produce a steady stream of commercially successful new products through industrial innovation.

- In the antibiotics sector, Japanese manufacturers are the world leaders in new compounds. For example, seven of the eleven new antibiotics developed in 1979 originated in Japanese laboratories.

- While expenditures of U.S.-owned companies for research at home and abroad are large and growing, they have not matched the expansion of foreign-owned firms' research efforts.

- The U.S.-located share of world pharmaceutical research has fallen from about two-thirds in the early 1960's to just above one-third today--higher growth rates for West Germany, Japan, and the U.K. have persisted.

- Manufacturers have been hampered by the lengthy testing required before bringing new products to market--new FDA proposals should help produce quicker and less expensive review.

Robotics

While the United States continues to lead in research and design, Japan has far surpassed it in robot production and use. International comparisions of robot usage vary significantly because of differing definitions of what constitutes a robot. But, even according to the more narrow U.S. definition, which excludes simple mechanical transfer devices, Japan currently has about three and a half times as many robots in use as the United States.

- Starting with technology licensed from the United States, Japanese manufacturers have developed robots for a broad spectrum of applications. Over 70 percent of all robots used in Japan perform machine-tool loading and assembly operations, compared with 21 percent in the United States. Japan's experience in this area, which is expected to be a major growth market, will give it an advantage in the U.S. market as it moves to increase exports.

- Several U.S. firms have entered into licensing arrangements with foreign companies to accelerate their own entry into the robot field. The belated but rapidly growing interest in the United States is due in part to the increasing economic justification for purchasing robots resulting from declining robot prices and rising wage levels.

Aircraft

The U.S. civil aircraft industry has traditionally dominated world markets. As late as the mid-1970s, U.S. manufacturers held 95 percent of the world's orders for airliners. Since 1975, however, foreign competition has intensified.

- The principal source of competition is from the government-funded European consortium Airbus Industrie, which captured 26 percent of the jet aircraft orders by 1981.

- During 1981, commercial airlines ordered a total of 235 U.S. aircraft. This contrasts sharply with the 360 ordered in 1980. On the other hand, Airbus Industrie's orders increased from 33 in 1980 to 45 in 1981.

- The relative level of U.S. aerospace R&D funding has steadily declined because of decreased federal funding. Foreign R&D capabilities, most of which are government funded, have expanded, allowing them to challenge U.S. technological leadership.

- While not yet capable of producing complete jet transports, various Japanese firms have entered into licensing arrangements to produce parts for U.S. and other foreign companies. This has allowed them to make significant inroads into component production while acquiring the technology to further their own aircraft development.

Biotechnology

Commercial success in biotechnology will depend heavily on the ability to identify potential applications of the technology and develop the necessary processes for large-scale production. Thus large amounts of venture capital have been supplied to many small biotechnology firms in the United States to support research and product development and testing, even though most of those firms have yet to realize any sales revenue.

Although the United States has the lead in recombinant DNA and cell culture technologies, there are gaps in its process technology and in the manpower available to meet future needs.

- Other nations are making substantial investments in the commercialization of processes, in which the United States has no clear lead.

- Japan has an undisputed lead in fermentation processes, a critical segment for commercialization, and is aggressively seeking to build on its strengths in this area.

Space

By the mid-1980s, estimated requirements for U.S. commercial space launch services will exceed the capacity of available shuttles. However, the United States will not have modern expendable launch vehicles available to augment the shuttle capacity. The French, with their Ariane launch vehicle, have initiated a marketing campaign to secure this traffic overflow.

- Space activity in the United States is controlled by the National Aeronautics and Space Administration (NASA). Payloads and launch dates are manipulated by NASA, with first priority going to military, rather than commercial, needs.

- Pricing of U.S. launches is artificially set by NASA, rather than through private negotiations between launch customer and launch-vehicle supplier. The French are able to offer the customer more favorable financing terms than NASA can.

- Budget restraints have limited the speed of commercialization of space. The evolution of expendable launch vehicles has slowed, as NASA turned all its attention and funding to the development and deployment of the Space Shuttle.

- The French Ariane has undergone considerable and rapid evolution to meet the needs of the commercial satellite industry.

- The Japanese are putting up satellites and in time could assume the launch support role for commercial satellites for Pacific rim countries.

Fiber Optics

Fiber optic technology has advanced rapidly since the late 1960s. It offers an ever-increasing range of applications, especially in the communications field. There are three components in a fiber optics system: light source, transmission medium, and detectors.

- Japan has a clear lead in light source technology and application and is competitive with the United States in the other component technologies.

- Japan's Ministry of International Trade and Industry has targeted optoelectronics for rapid development. The Engineering Research Association of Optoelectronics Applied Systems was established in 1980 to be the coordinator of government-subsidized projects in fibers optics and other optoelectronic R&D projects.

Computer Hardware and Software

The United States retains broad leadership in computer hardware and software production and technology. The Japanese have demonstrated strengths in the high-performance segment of computer mainframes.

- Japanese producers now have products that match the capabilities of major U.S. producers. Their equipment is also compatable--that is, it can run on U.S. software.

- Two U.S. companies have produced computers that are two and one-half times as fast as conventional mainframes. The Japanese are working on their own high-speed model and are expected to introduce a comparable computer later this year.

- Software productivity has not kept up with the expanded use of computers, especially microprocessor systems. One reason is the shortage of workers with key skills; another is the lack of standardization of programming languages and operating systems.

- Software costs in relation to total system costs are increasing. They now account for three-quarters of the cost of a typical computer.

Semiconductors

The United States no longer has the lead in several important areas of semiconductor technology. The U.S. position may be further weakened as many nations perceive that a viable electronics industry is essential to economic well-being and military security.

- Japan has an emerging leadership role in high-density computer memories. It now has well over 50 percent of the world market for the current state-of-the-art device.

- The Japanese also have strong capabilities in complementary metal-oxide semiconductor technology, favored for its low-power, radiation-resistant characteristics.

- Japan has an emerging semiconductor production equipment technology that will rival U.S. capabilities. Emphasis is on increasing the degree of automation of production facilities as well as improving its ability to produce devices with the smallest possible geometries.

- The West German and French governments have subsidized a number of programs to assist their microelectronics industries.

- The United States retains a solid lead in important microprocessor technology.

Machine Tools

While technically not falling within the definition of high technology, the competitiveness of the machine tool industry will increasingly depend on the use of microelectronics and computer-based technologies. A healthy machine tool industry is considered an important element of the U.S. industrial base.

- The U.S. share of worldwide production of machine tools has dropped from 37 percent to 17 percent. Japan's share, on the other hand, has grown from 5 percent to 13 percent. Western Europe has maintained a steady share of 15-20 percent.

- U.S. machine tool companies have not aggressively pursued foreign markets to offset slow periods in their highly cyclical market. Other countries, particularly West Germany and Japan, have actively penetrated the U.S. market. Imports now account for 24 percent of U.S. consumption.

- Computer numerically controlled (CNC) machines and flexible manufacturing systems (FMS) will play a major role in the machine tool industry in the coming decade. Japan has already made inroads in the U.S. CNC market and has targeted FMS as a specialty to mass market. Its early experience in this area will give it an advantage as demand increases.

IV. Factors Contributing to the Erosion of U.S. Competitiveness in High-Technology Industries

The dynamic interactions between economic, societal, and political forces have accelerated the development of foreign high-technology industries. The incentives and disincentives created by government policies can affect the willingness of firms to conduct research and attempt to exploit new processes and products in the marketplace.

General economic policies, particularly as they influence the rate of inflation, deserve attention because the United States has experienced a relative decline across much of the high-technology sector. The breadth of the decline suggests that overall economic conditions have had an important influence on competitiveness.

Structural differences in financial markets, relative changes in the level of research and development effort, and shifts in the availability of well-trained scientific and technical personnel have also affected U.S. competitiveness.

Overlaying these general economic and structural considerations has been the role of foreign governments in seeking to channel support to specific high-technology sectors. The success of these sector-specific industrial policies has depended to an important degree on the overall framework established by government policies which may be focused toward broader national objectives.

Although the transfer of U.S. technology has accelerated the technological growth of the rest of the world, it has not been a principal factor in the decline of U.S. competitiveness. The influence of technology transfer varies considerably in importance, depending on the recipient and the type of technology transferred. With respect to Japan, where aggressive policies of acquisition and absorption were pursued, it did lead to a change in relative competitiveness. In addition, in recent years, U.S. government policies that cover the transfer of military know-how to allies may have implications for competitiveness in a number of high-technology sectors, such as aerospace and electronics.

While this study examines several factors affecting competitiveness in high technology, these factors are only part of the problem. The ones highlighted are considered to be especially important. But a broader list would include relative prices, exchange rates, labor costs, relative productivity growth, relative quality of products, relative marketing effort, and relative cost and availability of export financing. (See Appendix D, which summarizes the factors affecting innovation.)

Lastly, though not discussed in detail, it should be recognized that international differences in management objectives can influence the nature of competition in high-technology sectors. If foreign firms are supported by a favorable economic climate, have access to adequate labor and capital resources, and have the technical know-how, their focus on objectives other than achieving sufficient return on their research investment can significantly enhance their competitiveness in high technology. U.S. firms require an adequate return on their prior investments in research to fund their present and future research investments.

THE OVERALL ECONOMIC CLIMATE AFFECTS COMPETITIVENESS IN HIGH-TECHNOLOGY INDUSTRIES

Innovative activity and the willingness to apply technological advances are directly and substantially affected by the general economic environment and government macroeconomic policies. To increase investor willingness to undertake high-risk investments with long-term paybacks, it is important to reduce uncertainty through:

- strong and steady economic growth;
- low and predictable inflation, to maintain cash flow for investment by preventing the erosion of the real values; and
- consistent government macroeconomic policies.

Before the 1973-74 oil price increase and the world recession that followed, the general economic environment was favorable to research and development, innovation, and capital formation in the United States, Japan, West Germany, and France. These events unfavorably altered the economic environment in all four countries, though less seriously in Japan.

For the last half of the 1970s:

- the rate of expansion of real economic activity slowed sharply in all four countries,
- the rate of inflation increased in all but Japan, and
- government economic policies became more volatile and lacked consistency as they switched between fighting inflation and maintaining high employment.

The pace of investment and innovation in Japan was adversely affected by the sudden 5-6 percent drop in its real growth rate in 1975. Nevertheless, the steadiness of the rate in the late 1970s--the real GNP growth range was 5-7 percent a year during 1976-80--restored the confidence of Japanese businessmen in the fundamental soundness of their economy. Even in 1981 and 1982, relatively dismal years for other countries, Japan will average more than 4 percent real growth. Each of the other countries had greater variations in real GNP growth in 1976-80, and each slid into recession last year.

Post-1975 inflation rates have been more favorable in Japan and West Germany. Despite the international tendency toward inflation, both countries price increases in the last half of the decade below those between 1960 and 1973. The lower rates of inflation indirectly promoted investment by helping to hold down interest rates.

In part, the relative shifts in macroeconomic performances in the late 1970s were conditioned by government economic policies. Tokyo and Bonn clearly chose to combat actual and latent inflationary pressures more strongly than recessionary problems. Monetary authorities of both countries held the growth in money supply to rates well below previous norms. On the other hand, French money stock growth was considerably more rapid than before 1973, and U.S. money growth was as rapid.

The effects of fiscal policy shifts on investment and innovation are not as clear. The United States and France have achieved the greatest success in limiting increases in budgetary deficits, but they did so by having government revenues as a share of GNP rise more quickly. In Japan and West Germany, higher private saving negated part of the adverse consequences of large deficits.

The recent emphasis on lowering the rate of inflation and eliminating the use of "stop-and-go" economic policies by the U.S. government is expected to provide a more conducive climate for innovation in the United States. Though the current recession has a negative effect, the decline in the underlying U.S. inflation rate suggests a movement toward a more favorable economic environment.

FOREIGN FINANCIAL MARKETS AND GOVERNMENT POLICIES MAKE CAPITAL CHEAPER AND MORE AVAILABLE TO U.S. COMPETITORS

High-technology firms generally compete in rapidly expanding markets that can change quickly with the introduction of new products or processes. The ability to quickly respond to new opportunities is essential.

International differences in the availability of capital may be crucial where substantial benefits accrue to firms able to rapidly expand. In many high-technology industries, costs decline with cumulative production volume. Therefore, rapid expansion allows a firm to realize lower costs and higher profits sooner than its competitors. Once a lead is established in an industry, the effects can become reinforcing: the leading firm generates more funds for investment and thus can afford to expand at a faster rate and further increase its lead over its competitors.

Differences in the cost of capital between the major developed countries are also important to competitiveness. Financial capital is like any other resource consumed by a firm: its cost must be reflected in the price of the goods and services the firm provides. As competition in high technology becomes more oriented toward price and quality, lower-cost capital can influence competitiveness.

Tax policies are one of the factors that can influence the cost of capital. Through a variety of provisions, governments can seek to reduce the cost of capital. Special reserve accounts have been one important mechanism. While legal constraints may limit the uses of these funds, reserve accounts effectively constitute an interest-free loan from the central government and provide additional maneuverability by lowering corporate demand for external funds.

- Japanese, French, and West German firms benefit from tax deductions for special reserve accounts. In Japan special reserve allowances have also been legislated to encourage specific corporate undertakings, such as the application of computer-aided design and robotics.

- By the end of 1978, "reserves and provisions" uniformly comprised almost two-thirds of French and Japanese and one-third of West German equity holdings. Moreover, foreign firms have uniformly experienced a continued growth in allowable reserves and thus benefited from a constant stream of tax-free income.

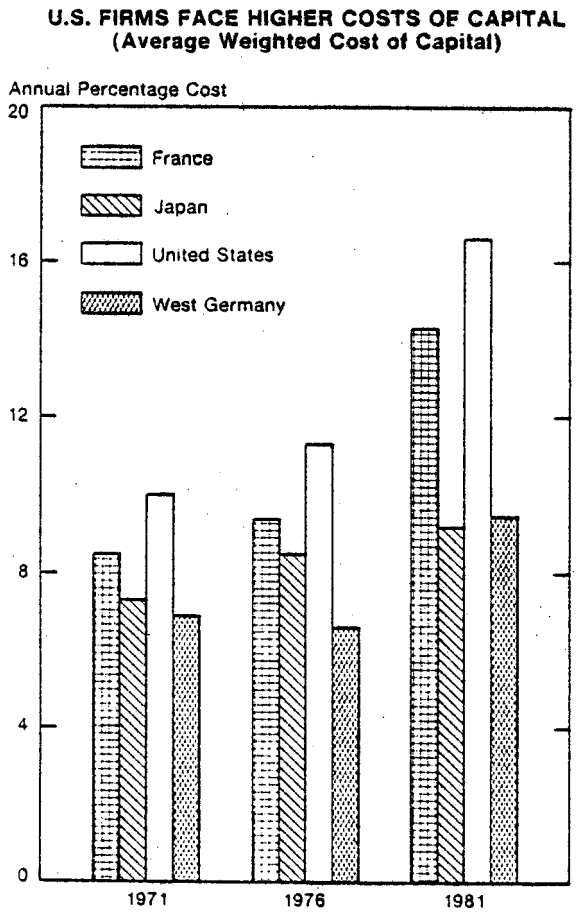
The financial markets in Japan, France, and West Germany are organized to make low-cost finanical capital available to favored industrial sectors. The French and Japanese governments especially emphasize the use of their banking systems to influence the pattern of industrial growth. Such government intervention can significantly distort the operation of financial markets. While these policies may not necessarily result in the

most profitable or the most productive use of financial resources, they are attempting to fulfill a variety of foreign political and social objectives.

United States

High capital costs can be striking in their effect, particularly when international differences exist. For example, last year, when U.S. corporations typically faced a weighted cost of capital of 16.6 percent, the total cost of a $100 million investment financed over 15 years exceeded $900 million. In Japan, where the weighted cost of capital was only half as high, this same investment cost $374 million or 60 percent less. Even allowing for differences in relative depreciation schedules, the stream of returns necessary to cover capital costs is much higher in the United States than in Japan. (See Appendix E for a more detailed discussion on the determinants and differences in the international cost of capital.)

Figure 4.1



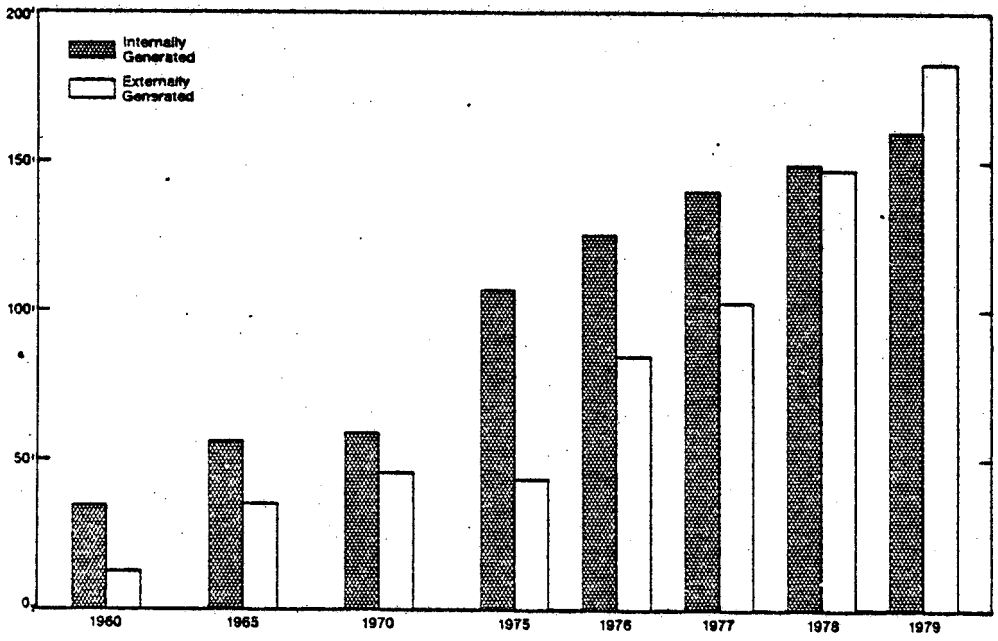
Throughout the 1970s American companies, on average, paid a higher price for financial capital than their competitors in West Germany, Japan, and France. This difference has widened significantly during the last five years. By 1981, U.S. industry's capital costs were more than twice those of its competitors in West Germany and Japan.

Relatively higher U.S. inflation rates, which tend to increase a firm's estimate of future nominal returns, may have mitigated the effects of these higher capital costs in the past. Currently, however, they do not sufficiently offset them or compensate for the more volatile U.S. sources of funding. External funding has increased significantly relative to internal funding. These factors have reduced the willingness and ability of U.S. corporations to engage in anticipatory or rapid capacity expansion or in other forms of high-risk investment.

Figure 4.2

U.S. Corporations Are Increasingly Relying On External Sources of Funds

$Billions



'Internal sources include: Undistributed profits, Adjustments, and Capital consumption allowances. External sources are defined as net increases in corporate liabilities.

Source: Statistical Abstract of the United States, 1980; Table No. 945.

Internal cash flow is normally the preferred source of funds for innovative activity. Industry structure, corporate tax policies, sales volume, profit margins, and investor demands for a return on investment strongly influence the generation of internal cash flow. External funds are raised through stock issues, bond sales, and borrowing. Host financial markets and a corporation's relationship with its lenders greatly affect both how these funds are raised and corporate reliance on them. Normally, firms are hesitant to externally fund high-risk projects, especially if the payoff may not be realized for a number of years.

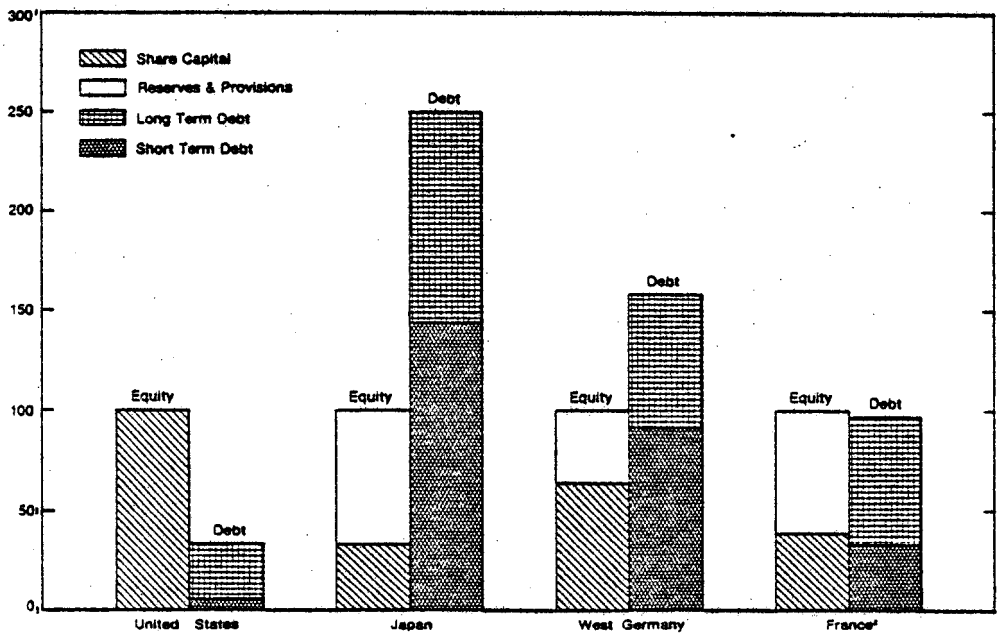
In the United States, the household sector is a net provider of funds to the business and government sectors. In previous years, the U.S. savings rate has been substantially below that of its

competitors. A comparison of average household savings rates for the 1976-80 period reveals a great disparity: Japan, 20 percent; France, 16 percent; West Germany, 14 percent; and the United States, 6 percent. While part of the difference may be attributed to cultural and institutional differences, one factor historically has been the insufficiency of incentives for increased savings. The incentives to savings in the administration's Economic Recovery Plan, however, should increase U.S. capital availability.

The U.S. system is further characterized by substantial direct acquisition of capital through equity financing and borrowing, principally from the household sector. U.S. corporations have relied relatively less on debt as a source of funds than have their foreign competitors. As a result, they have tended to put more emphasis on short-term profitability in assessing investment programs.

Figure 4.3

Composition of Corporate Liabilities in 1979
(Value of Equity Holdings = 100)



Composition of Corporate[1] Liabilities in 1979. Value of Equity Holdings = 100.

[1]Manufacturing sector for Japan & West Germany; French industry; all non-financial institutions in the United States.
[2]French data for 1978.

Japan

Japan's success in high-technology industries has been partly due to the ability of its large, integrated corporations to divert cash flow from the mature business segments, as well as their ready access to external sources of low-cost capital. Rather

than relying heavily on equity, as the United States does, Japanese firms use bank financing extensively. Japan has 13 major city banks backed by nationwide branches. This limited number has centralized the supply of investment capital, allowing major corporations to efficiently raise funds.

More importantly, central bank rate supervision has often kept interest rates below market clearing levels. As a result, the major city banks periodically need Bank of Japan refinancing and thus become subject to government guidance on allocating loans among industries. This guidance bolsters bankers' confidence in the ability of targeted borrowers--those firms integral to the accomplishment of the Ministry of International Trade and Industry's vision of industrial development--to sustain high debt levels. Although most commercial bank lending is short-term, explicit or implicit rollover agreements allow Japanese corporations to view short-term loans as long-term liabilities.

In recent years, overall reliance on borrowing has declined because of higher profitability and more liberal provisions in the tax code for reserves. These favorable factors have also created new opportunities for direct financing via stock and bond issues. But a low dependency on the sale of equity shares and bonds as a source of funds continues.

In general, Japanese companies have traditionally benefited from higher levels of gross cash flow than their competitors. Moreover, stable prices have kept down the cost of replacing capital, freeing a greater share of internal funds for new programs. Specifically, Japanese firms benefit from:

- higher leveraging, which allows substantial tax deductions for interest payments; and
- reserve accounts, which yield a sizable and sustained tax shelter for corporate income.

Japan has widely used tax incentives to stimulate selected high-technology sectors, including the microelectronics and computer industries. For example, in addition to ordinary depreciation allowances, there are special types of depreciation, including one-time initial write-offs and accelerated depreciation. Revenue losses attributable to promotion of science and technology have been rising and constitute approximately one-quarter of Japanese tax preferences.

France

The French capital market reflects the pervasive influence of the central government in controlling economic activity and its desire to ensure the availability of long-term capital for

corporate investment. It is characterized by an extremely complex set of financial intermediaries, most under government control, which together channel household savings into corporate investment.

French firms depend heavily upon bank lending to supplement internal funds. In 1970-79, financial institutions supplied over 75 percent of the funds French corporations raised in France. The market for stocks has traditionally been limited, while the bond market has been dominated by the nationalized industries and special credit institutions.

The Banque de France closely controls the amount and cost of capital available to firms. As in Japan, commercial banks rely on central bank refinancing of medium- and long-term industrial loans and are thus subject to administrative guidance.

Citing French commercial bank caution in lending, the relatively high interest rate to corporate borrowers, and the excessive weight accorded short-term profits in deciding among potential borrowers, the Mitterrand government has introduced legislation that will result in a nationalized banking sector directly or indirectly controlling 97 percent of all resident deposits and 93 percent of all loans. The government expects that this additional control will enable it to ensure that lending criteria are adjusted in favor of long-term investments judged to be in the national interest.

West Germany

The West German financial system is characterized by a high level of personal savings and the banking system's crucial role in attracting long-term deposits and reloaning them to industry. In 1970-79, roughly 80 percent of corporate financing was in the form of fixed-interest loans for ten years or more.

While West German banks often play a major role in corporate decision making by virtue of their major equity holdings, the central government has not taken advantage of the financial system to guide lending activities. Financial policies are generally macroeconomic, with specific lending institutions providing sectoral assistance.

The interlocking relationship between the financial and industrial sectors is perhaps greatest in West Germany. In 1980, banks voted an average of 63 percent of the corporate shares voted of the 74 largest West German corporations. The three largest banks alone accounted for 35 percent of the shares voted.

As financial advisers and large holders of voting rights, banks can have considerable influence over a firm's behavior. At a minimum, banks are interested in ensuring that decision making is consistent with long-term return to capital and, thus, the ability to repay the extensive long-term bank exposure. The firms benefit from the information bankers are able to bring to their board rooms and from the greater degree of certainty that financial support exists for corporate decisions.

To emphasize investment as a means of stimulating the economy, the West German government has sponsored a number of programs to compensate for perceived capital deficiencies. In particular, it has attempted to compensate for the virtual absence of venture capital and the growing reluctance of commercial banks to finance small- and medium-sized firms. For example, the government sponsored an independent organization formed by a consortium of banks with the goal of providing venture capital for high-risk projects.

OTHER COUNTRIES ARE COMMITTED TO INCREASING THEIR RESEARCH AND DEVELOPMENT EFFORTS RELATIVE TO THE U.S. EFFORT

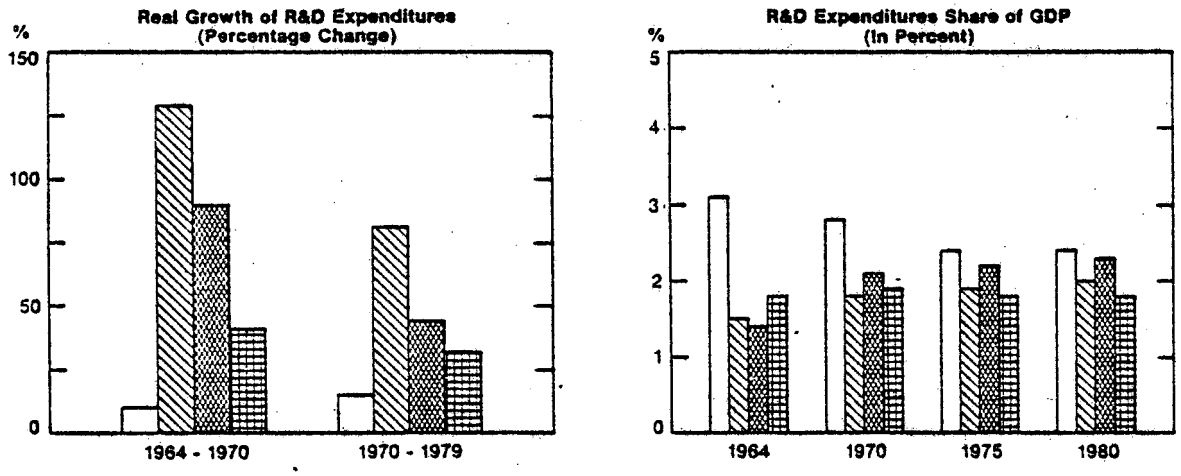
Both government and private industry support high technology by sponsoring research and development programs. An examination of trends in R&D in the United States, Japan, West Germany, and France reveals significant changes in overall relative growth in real R&D expenditures and in how those expenditures are allocated among the different types of research. It also shows a dramatic increase in U.S. industry's share of R&D spending, along with the U.S. government's strong shift from defense-related to civilian projects.

Overall R&D Funding

In absolute terms, the United States supports the largest amount of R&D. In 1977, for example, U.S. private funding of industrial R&D was about 40 percent greater than the sum of the corresponding figures for Japan, West Germany, and France. But since 1964, R&D funding from all sources has increased more rapidly in these three countries than in the United States. These differences in growth reflect in part, a growing willingness by these other countries to invest a constant or increasing proportion of their gross domestic output in R&D.

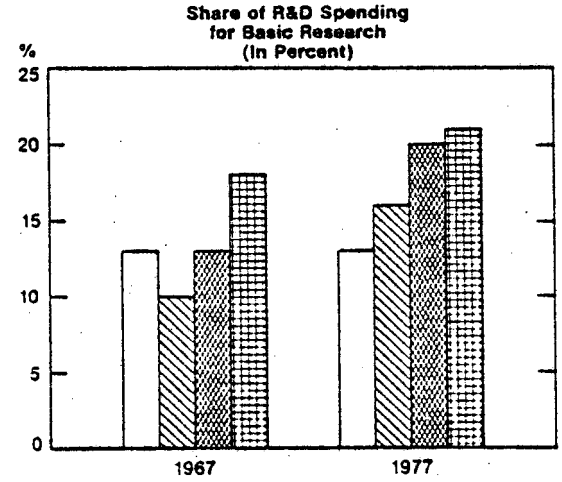
Figure 4.4

Selected Indicators of R&D Funding for the United States, Japan, West Germany, and France



There have also been significant changes in allocation of R&D spending among basic research, applied research, and development across the four countries.

Figure 4.5



Between 1967 and 1977, in real terms, Japan increased its proportion of R&D funds for basic research by over 60 percent, West Germany by over 50 percent, and France by over 16 percent. The proportion of U.S. spending adjustment for inflation allocated to basic research, however, remained constant throughout the period.

LEGEND:

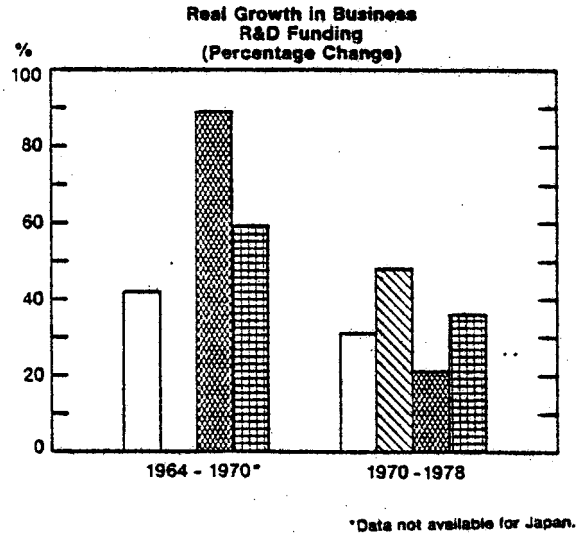
United States
West Germany
Japan
France

Source: OECD, Science and Technology Indicators Unit.

Business R&D Funding

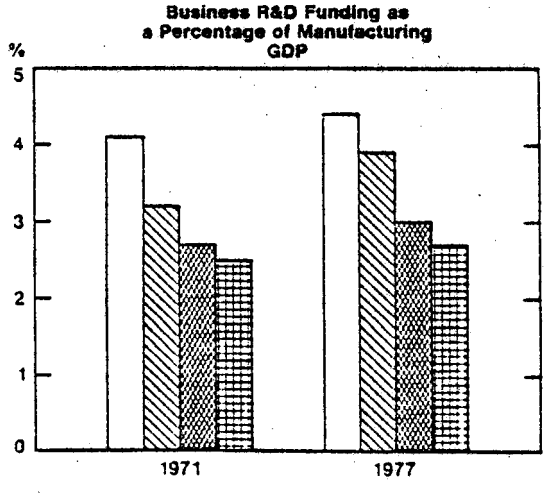
With regard to business funding of R&D, U.S. performance compares favorably for the 1970s.

Figure 4.6



During 1964-70, firms in West Germany and France expanded their R&D funding at substantially higher rates than U.S. firms. During the 1970s, however, growth in U.S. business funding of R&D surpassed that of West Germany and almost matched the French growth rate. Meanwhile, R&D spending by Japanese firms grew over 50 percent faster than that of U.S. firms.

Figure 4.7



A look at business R&D funding relative to the share of the business gross domestic output apportioned to R&D for manufacturing activities also shows U.S. business favorably.

LEGEND:

United States
West Germany
Japan
France

Source: OECD, Science and Technology Indicators Unit.

Because the United States is increasingly relying on private business to fund research, a greater share of U.S. research will be influenced by the vagaries of the market. For example, a recent trend has been for U.S. businesses to favor research projects with short-term benefits relative to those with long-term benefits. This tilt toward shorter-term projects is partly the result of the volatile U.S. rates of inflation. Thus projects with long-term economic and social benefits tend to be underfunded.

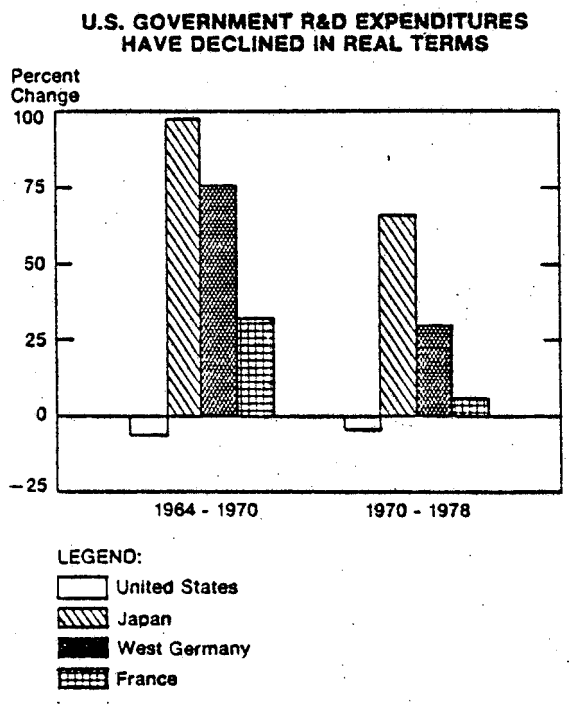
Government R&D Funding

The four countries show major changes in goverment R&D funding patterns during 1964-78. These differences may well have influenced these countries' rate of development of commercial technologies during the past ten to fifteen years.

Governments in all industrial nations fund R&D for at least three purposes:

- to meet government needs (e.g., defense);
- to enhance the science and technology infrastructure (scientific knowledge, training of scientists and engineers); and
- to stimulate development of commercial technologies (in the United States, the major beneficiaries of this type of research support have been agriculture and energy).

Figure 4.8

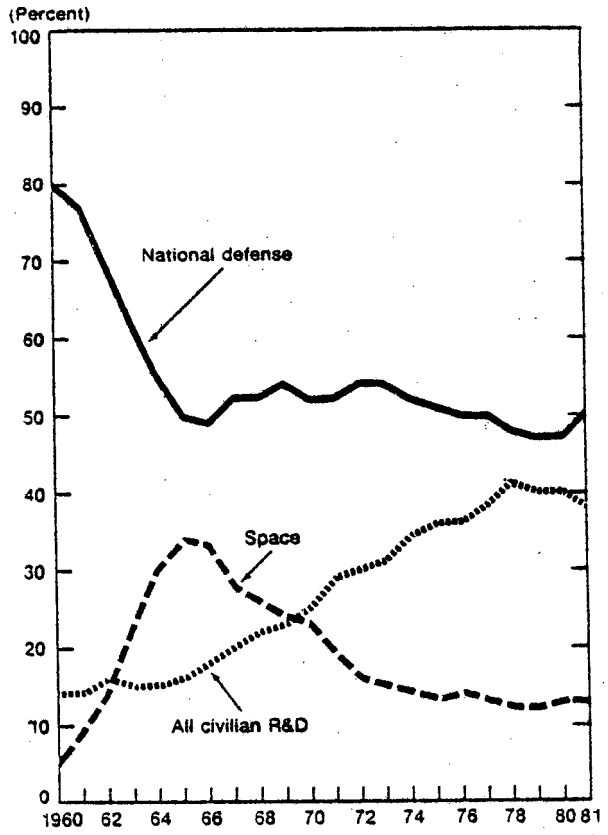


Source: OECD, Science and Technology Indicators Unit.

From 1964 through 1978, real government R&D expenditures in the United States declined slightly. During 1964-70, the governments of Japan, West Germany, and France greatly increased their R&D spending, while from 1970 through 1978, only Japan and West Germany continued this rapid expansion.

Figure 4.9

U.S. GOVERNMENT OBLIGATIONS FOR R&D BY MAJOR BUDGET FUNCTION



Note: Estimates are shown for 1980 and 1981.

Source: NSF, Science Indicators—1980.

The major proximate factor in the decline of U.S. government spending for R&D was the sharp cutback in defense and space R&D during the late 1960s and early 1970s. At the same time, other major components of U.S. government R&D did not increase enough to completely offset this reduction. Current budget projections, however, show R&D relative expenditures shifting back to defense.

In contrast, the governments of Japan, West Germany, and France accelerated their R&D efforts in several areas to narrow the U.S. technological leadership. For example,

- all three countries increased their R&D outlays for nuclear energy programs;
- European nations, led by France and West Germany, undertook a space satellite program and development of the Airbus;
- in France and Japan, the governments allocated substantial funds for electronics R&D.

THE U.S. ADVANTAGE IN SCIENTIFIC AND TECHNICAL PERSONNEL IS DECLINING

The availability of large numbers of well-trained scientific and technical personnel has long been recognized as a significant contributor to the competitive strength of American high-technology firms. Recent trends, however, reveal that not only is this relative advantage diminishing, but the relative quality of the U.S. technical pool may also be declining.

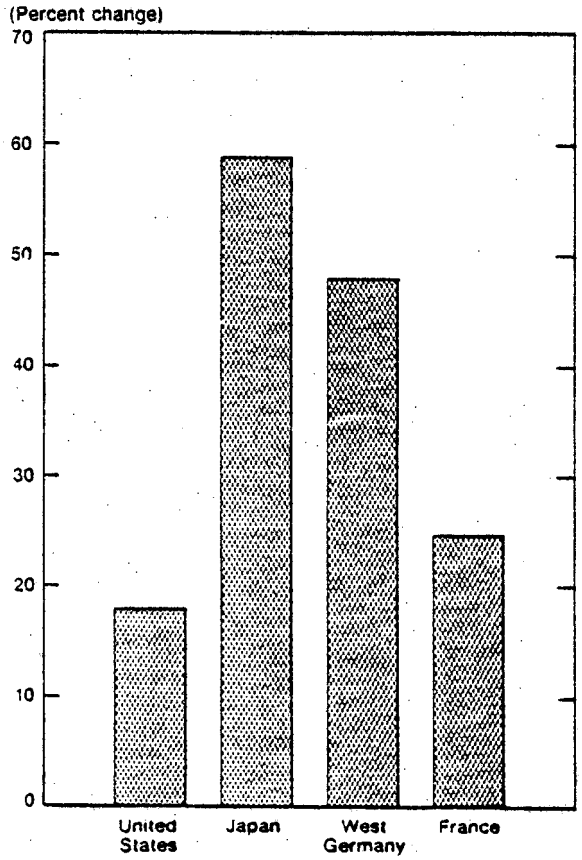
Shortages of Well-Trained Scientists and Engineers

The following trends during the 1970s illuminate the problem:

- Employment of scientists and engineers in R&D rose considerably more rapidly in Japan, West Germany, and France than in the United States.

Figure 4.10

GROWTH IN SCIENTIFIC AND ENGINEERING PERSONNEL, 1970 - 1979
(Percent Change)



- The percentage each country contributes to the total number of scientists and engineers employed in R&D across all four countries illustrates the significant changes in relative positions. Japan moved up to almost 25 percent from 20 percent of this total, while the U.S. proportion declined from 63 percent to 57 percent.

- When examined against labor force trends, these relative changes become even more significant: the labor force in the United States grew by 24 percent; in Japan, by about 6 percent; and in France, by roughly 5 percent. In West Germany, it actually declined by 6 percent.

- There has been a noticeable "graying" of America's engineering work force as the percentage of younger engineers in the pool has fallen. Since the obsolescence of knowledge occurs rapidly, especially in areas where R&D is extensive, an aging engineering work force is likely to be less creative.

As a result of these trends, during the 1970s, the U.S. labor market was characterized by shortages of personnel in several high-technology specialties. Most prominent among the shortages or tight labor market conditions reported during this period were those for all types of computer specialists. This reflected the burgeoning applications of computers throughout the economy and their related servicing industries. Similar situations were reported for electronic specialists and chemical, electrical, and industrial engineers.

The increases in salary levels in the private sector, which resulted from a tight labor market, seriously affected recruitment of instructors for U.S. engineering school faculties (currently, there are 1,600 faculty vacancies) and for the U.S. armed forces (where pay scales did not keep up with the private sector). These increases also caused a sharp drop in the number of engineering Ph.D. candidates.

Upgrading the Quality of Science and Engineering Education

The quality of secondary and postsecondary educational programs will be important to the competitive positions of advanced economies. Not only with respect to enhancing the education of future engineers but also to upgrade skills of the existing work force. In the past, U.S. industry has made less use of the option of upgrading the skills of older personnel than its foreign competitors, whose governments encourage systematic upgrading.

Although the United States retained a substantial, if reduced, overall lead in the employment of scientific and technical personnel, the relative upgrading of the quality of the overall labor force was greater in the other countries, particularly in Japan.

United States

The lack of universally high standards in mathematics and the sciences in U.S. secondary schools, along with a lack of emphasis on these disciplines, seriously handicaps attempts to broaden the U.S. base for training scientists and engineers. This has been cited as a major factor in the relative decline of the "technological literacy" of the U.S. labor force.

At the university level, however, the United States remains strong. Education in science and engineering at U.S. universities compares very favorably with postsecondary education in competing nations. The relative adaptability of the U.S. engineering schools, as compared with their foreign counterparts, has been a strength. For these reasons, U.S. universities enjoy a strong international reputation and attract large numbers of foreign students.

Japan

The Japanese have a policy of emphasizing scientific and technological training. The strong background average Japanese factory workers have in science and mathematics is one explanation of their superior understanding of the technological aspects of production.

Scientists and engineers enjoy a very high status in Japan. This has been reflected by the 65 percent of the baccalaureates who opt for scientific fields at the university level (as contrasted with 30 percent in the United States).

The relationships among universities, the government, and industry are very close in Japan and mostly maintained by informal channels.

West Germany

West German secondary education for those heading for universities also has much more required training in mathematics and sciences than U.S. schools. About 75 percent of those who graduate from the upper secondary school go on to universities, and roughly one-third of this group seek degrees in science, engineering, or mathematics.

France

The highly centralized French educational system has rigid secondary school requirements in mathematics and science studies for those planning to enter higher education. Those entering higher education either go to the very select Grandes Ecoles, for which the competition is very great, or to ordinary universities. Despite the rapid expansion in requirements for engineers in France, the Grandes Ecoles have not been allowed to expand significantly.

Graduates from the select French engineering schools are destined for careers as technical administrators in the government and industry, while those with degrees in the sciences or engineering from ordinary universities do not carry such a cachet to success.

FOREIGN GOVERNMENT INDUSTRIAL POLICIES AFFECT COMPETITIVENESS IN HIGH-TECHNOLOGY SECTORS

The growing government use of active policy instruments has resulted from the pressures of a number of economic and political changes in the post-World War II period. Nations have continued their efforts to develop industrial structures that satisfy their political, social, and economic objectives. Yet they have also pursued policies that reduce barriers to trade, including reducing tariff and nontariff barriers in the Multilateral Trade Negotiations.

The industrial policies of the advanced economies of Japan, France, and West Germany were developed in response to international and domestic political and economic pressures. An additional dimension creating concern in high-technology industries is the perceived acceleration of technological change. This combination of forces is now pressing the advanced countries to adapt to changes both between their respective economies and with respect to developing countries.

These changes are not simply cyclical expansions or contractions in business activity. Rather, they are changes in the fundamental nature of world economies requiring a substantial emphasis on service sectors and modifications within industrial sectors. Because the problems stem essentially from the supply side, appropriate adjustments will require substantial time.

So competitive pressures have been increasing across the board. These pressures have been buttressed by the escalating significance of economies of scale in achieving competitiveness in high-technology sectors, the increasing costs of R&D and innovation in key sectors, and the lengthening lead times for

developing new products. These three factors have raised the barriers to entry in a number of industrial sectors andemphasized the significance of a correct strategy.

Carried out with the necessary infrastructure of low-cost, readily available capital, a strong commitment to research and development, and abundant, highly trained personnel, foreign government industrial policies promoting indigenous development of selected high-technology sectors can influence competitiveness.

- Foreign governments have developed a number of instruments which have strengthened their research infrastructure concurrent with their efforts to target sectors for accelerated development.

- The emergence of foreign high-technology firms supported by favorable government programs affects the ability of U.S. firms to conduct R&D.

In adopting industrial policies for higher-technology sectors, governments usually state as their principal objective the identification and acceleration of activity in potentially strong sectors to gain larger shares of international markets. In some countries, these policies lead to the government's selecting "national champions" or strengthening state-owned enterprises to be used as the competitive leaders.

At present, industrial policies are based wholly on national considerations. Only within a given country are the processes and procedures perceived to be available to make the required nonmarket decisions. The response to the pressures from international competition is to beef up national capabilities, rather than to seek an intergovernmental solution. All the criteria of location and distribution of benefits come from the national interests, and the objective is to protect national power and wealth through maintaining as high a growth rate as possible by restructuring industry.

Foreign industrial policies in the high-technology sectors can weaken the ability of U.S. firms to realize adequate returns by driving down the returns for research, investing in the ownership of U.S. firms active in promising technologies, signaling intentions in the marketplace not to permit U.S. firms to achieve adequate returns, ignoring or bypassing patent or copyright protection, and sometimes requiring know-how to be transferred as a condition of access to foreign markets. Thus, for U.S. firms engaged in research, the already high risk is amplified once a determined foreign competitor enters the field with government support.

The governments of France and Japan have similar objectives and techniques for industrial policies. They are more directly involved in sectoral guidance than are Germany and United States, with the United States being at the extreme by providing virtually no such guidance.

Japanese Industrial Policy

During the past two and a half decades, the Japanese government has employed a wide range of programs. These include funds for modernization and development, rationalization cartels, establishment of standards, preferential tax rates, consolidation of enterprises, and the establishment of joint ventures.

Japan's national industrial plan identifies sectors the government considers to have the best prospects for technological advance and international competitiveness and then adopts supporting techniques. The process started in the late 1950s when Japan shifted the emphasis of its industrial policy from improving individual company efficiency to concentrating its activities on priority sectors. For these sectors the government restricted imports, prohibited foreign investment (except as minority partners), and encouraged imports of foreign technology.

In the late 1960s and during the 1970s, Japan encouraged greater specialization and economies of scale. In the early 1970s, emphasis shifted toward R&D assistance and sales of entire plants abroad. A number of Japanese institutions work together to promote such sales.

The Japanese government's current plan is laid out in a document entitled "Industrial Policy Vision of the 1980's," published by the Ministry of International Trade and Industry (MITI) in April 1980. It sets priorities, and industry sectors are expected to respond appropriately.

The objective of Japanese industrial policy in the high-technology sectors is to anticipate and accelerate signals from the market. Consequently the Japanese government supports R&D activities, capital expenditures, and export efforts.

- Through the Japan Development Bank and the Industrial Bank of Japan, MITI and the Ministry of Finance provide financial assistance.

- In addition, MITI will support a selected group of R&D projects and technologies proposed by key companies in these sectors. Participating companies share in the development work, in the know-how generated by the project, and in the rights to patents.

The industrial sectors to be emphasized in the 1980s are twelve so-called knowledge-intensive industries. Adding these to those already selected for the 1970s results in about twenty-four specific sectors to be given governmental support.

Information electronics is supported through substantial R&D subsidization--such as the $400 million research joint government-industry effort in microelectronics in the late 1970s and the special assistance given to software development.

- On the marketing side, the government has supported companies purchasing computers. It offers financial asssitance and has established a joint venture with private enterprise to lease computers. The government also reserves about 90 percent of its purchases for Japanese producers.

- In telecommunications, it has been difficult to open up purchasing to foreign bids. Nippon Telephone and Telegraph Corporation (NTT) not only has given a preference to Japanese suppliers, but has directly supported the R&D of the major telecommunications equipment suppliers and has helped finance their exports.

French Industrial Policy

French industrial policy has been highly selective, pragmatically shifting between market and nonmarket approaches to meet whatever pressures seemed to need countering.

Before the mid-1970s, French industrial policy was aimed at preventing the takeover of French industry by foreign firms and at strengthening it through consolidation. It also strove to enhance French industry's ability to compete effectively with European firms, anticipating further European integration.

During the 1950s and early 1960s, the French government used a wide variety of techniques to stimulate industry, encompassing virtually all those used currently. For example:

- it selected certain sectors for encouragement, providing government education about R&D assistance;

- it encouraged mergers and consolidation;

- it created investment-banking facilities to provide risk capital;

- it protected industry from international competition;

- it deliberately exposed selected industries to international and domestic competition to force efficiency and competitiveness;

- it allowed cartel-like groupings of industry to try to achieve competitiveness; and

- it encouraged specific sectors to cut their losses short when competitive forces were overwhelming.

The government directed its promotion efforts at high-technology sectors, including nuclear energy, aircraft and space, energy conservation, electronic data processing, and telecommunications. It used a variety of techniques, including government purchasing, tax incentives and direct financial assistance, and special funds for distressed regions. In addition, it concentrated on stimulating consultation of companies with labor, strengthening the capital markets, and supporting R&D in key industries.

The planning structure for guiding a sector may be fairly simple or complex. In the case of the computer-related electronics industry, France has four separate plans: the Plan Calcul, for the mainframe computer; the Plan Composants, for microelectronic components; the Plan Peripherique, for EDP peripheral equipment; the Plan Software; and the Plan Electronique Civile and the Plan Mechanique for the entire electronics and mechanics industries. In formulating these plans, the government works closely with industry.

A major feature of France's pre-1976 policy was that the criterion of success was achieving international competitiveness--preferably without, but if necessary with, technological assistance from abroad. It sought to promote high-technology industries through government investment in "national champions" in various key projects and through the selective admittance of foreign firms that could accelerate technological innovation in cooperation with French companies. Once they have become concentrated, however, these "champions" have responded poorly to consolidation and the competition.

The techniques have shifted somewhat from direct government guidance of specific sectors and firms, to greater reliance on market signals and enterprise strategy with stimulants to growing enterprises, so as to hasten market processes. These moves have brought French policy closer to both German and Japanese practice.

Only France and Japan have publicly announced the selection of target industries for future government support, and the lists are virtually identical.

Examples of France's commitment to enhancing the competitive edge of targeted industries include the following policy actions:

- Tax deductions have been offered to people who purchase shares on the stock exchange, and mergers are being restricted.
- A five-year, five-billion-franc support program for electronic data processing and telecommunications equipment is in place.
- The Ministry of Research and Technology has increased spending by 33 percent, aiming to raise total spending from 1.8 percent of the GNP to 2.5 percent by 1985.

West German Industrial Policy

During the 1960s and early 1970s, the West German economy was considered a "free-market miracle." Substantial government assistance, however, was instrumental in making this miracle possible.

During the early 1970s, the government recognized that if German industry were to remain competitive internationally, it had to shift out of the low-skill, low value-added products that were being undertaken by the developing countries.

- Through grants, low-cost loans, and tax concessions, the government increased its support to the high-technology sectors. For example, West Germany participated in Europeanwide projects in nuclear energy and aerospace. By the late 1970s, the West German programs and techniques employed were not significantly different from those of France.
- A new science and technology ministry was created to provide federal R&D funding.

Since the late 1970s the government has been increasing its funding for R&D, especially in aerospace ventures in cooperation with other European countries and in the West German microelectronics industry. It helped finance firms buying data processing equipment and provided additional funds for R&D in energy-related projects. However, it has no priority list of sectors to be supported. The government responds and guides, but it does not lead.

The system of consensus, developed in West Germany since World War II, lets the individual companies lead. They respond essentially to market signals, but with guidance from the banks with which they are associated. In addition, labor has significant input through the system of "codetermination." Consequently, there is a degree of concerted action called "concertation," involving three-way dialogues among business, government, and labor. Through this system, information is fairly widespread, and adjustments to perceived changes are more rapidly made. These adjustments are not made under a system of planning, where goals are projected, but simply through collegial decisions to adjust to market changes.

THE TRANSFER OF TECHNOLOGY HAS ACCELERATED THE TECHNOLOGICAL ADVANCE OF U.S. COMPETITORS

The transfer of U.S. technology by the private sector has helped foreign industry approach or equal the technological sophistication of the United States. This has been particularly true in the case of Japan. But compared with all other factors, the transfer of U.S. technology cannot be considered the principal cause of the decline of U.S. competitiveness, because the ability to apply technological developments must exist before knowledge of technological advances can be of any use. Avenues for the transfer of technology also exist through the weapons-related international cooperative programs of the Department of Defense.

The Transfer of U.S. Civilian Technology

Although a case-by-case analysis may reveal instances where the transfer of U.S. civilian technology has adversely affected U.S. competitiveness, from a broad perspective, the available data do not identify it as being a major factor. To directly undermine U.S. international competitiveness, the technology must be transferred to a foreign firm unrelated to the U.S. firm, with insufficient compensation, or must fall into the control of foreigners faster than leakage would occur without a transfer. Although the evidence is that U.S. firms have been more willing in recent years to transfer technology overseas, this tendency applies, for the most part, to transfers between related parties, primarily foreign subsidiaries of U.S. firms.

- There is a very stable relationship between U.S. receipts from foreign affiliates and outgoing U.S. direct foreign investment. The ratio of the former to the latter stayed between 5 percent and 6 percent during 1967-78, suggesting that the transfer of U.S. technology to foreign subsidiaries increased at about the same rate as outgoing direct foreign investment.

- The two manufacturing sectors--machinery and chemicals--that have accounted for the major shares of U.S. receipts of royalties and licensing fees as well as U.S. direct foreign investment activities abroad have also accounted for the major share of U.S. manufactured exports.

- Transfers of technology are increasingly taking place on a barter basis, so the estimates of returns technology transfers bring U.S. firms will be conservative.

Department of Defense Weapons Programs As Avenues of Technology Transfers

Transfers of technology take place through various Department of Defense programs operating within the framework of NATO and U.S. relations with Japan. These programs were originally designed to enhance U.S. interests by strengthening the military power and defense-related industrial capacity of U.S. allies. Now, with the increased ability of European and Japanese industry to apply technological advances, these programs affect U.S. technological competitiveness.

Coproduction and Codevelopment

Technology transfers take place largely through the avenues of coproduction and codevelopment. These programs seek to reduce the production cost of weapons systems by avoiding duplication of resources and to promote the technically advanced, industrially productive, and economically viable defense industries of U.S. allies.

Technology transfer under these programs is a major defense-related issue. Coproduction and codevelopment have been important in integrating and strengthening the defense-related industrial base of U.S. allies, and the United States has benefited from technology transferred from its allies. But, on balance, U.S. allies have been the greater beneficiaries from these transfers because of the more advanced level of U.S. military technology. In recent months, the Department of Defense has been reassessing the interest of U.S. national security as related to technology transfer to U.S. allies under military programs.

Offsets

Another important defense-related instrument of technology transfer from the United States to its allies has been the policy of "offsets." Initially, offsets were related to the balance of payments in connection with arms sales. They committed the seller to "offset" the imbalance in arms trade by applying a certain percentage of the purchase price to purchases from the buyer nation. In recent years, however, offsets have in many cases lost their relationship to the consideration of the balance of payments and have simply become a certain favorable condition, other than the price, that the buyer extracts in connection with a purchase. In some cases, the size of the offset exceeds the price of the arms purchase.

The practice of offsets has become intricately intertwined with the various activities conducted under the coproduction and codevelopment programs. Technology transfer, in various forms, plays a part in offsets. For example, a coproduction agreement by a manufacturer may become an offset in a major arms sale.

Japanese Technology Transfer Policies Compared with West German and U.S. Policies

In contrast to other U.S. competitors, Japan has implemented specific technology transfer policies aimed at improving its international competitiveness. It was not, moreover, an isolated instance of government intervention targeted specifically at Japan's international technology transactions. It formed an integral part of Japan's national industrial policy.

After World War II, Japan instituted a national control system over technology transfers, based on the Foreign Exchange and Foreign Trade Control Law of 1949 and the Law Concerning Foreign Investment of 1950. All technology transfer contracts and direct foreign investment projects had to be screened and approved by the Japanese government. The government believed that without its direct controls, Japanese industry might fall under the domination of foreign interests. This concern dated back to the initial industrialization effort of the post-Meiji Restoration (1868).

The government sought to exert a countervailing power on behalf of the Japanese firms vis-a-vis their foreign competitors, who had superior technologies. It also discouraged competition among rival Japanese firms in their efforts to gain access to foreign technology. This, too, was intended to strengthen the bargaining position of Japanese technology purchasers. The government encouraged "staggered, orderly entry" by individual firms into specific industries, allowing the initial entrants to establish

temporary monopolies based on imported technologies. In another effort to improve their access to technology, Japanese companies expanded foreign investment in research-intensive countries, such as the United States and West Germany.

Imported technology has contributed to Japan's exceptional economic growth, but it was only part of an overall strategy.

- In recent years, imported technologies have become a complement to rather than a substitute for domestic R&D and innovations.

- In the 1970s, Japan put greater emphasis on importing technologies that had not yet been commercially exploited in the transferring countries themselves.

- In the past, Japan's domestic R&D efforts were geared primarily toward modifying, adapting, and improving imported technologies. Now, however, it is targeted at the high-risk stage or areas with the potential for major technological advances.

V. Implications for the U.S. Economy and National Security of an Erosion of U.S. Strength in High-Technology Industries

The United States occupies a unique leadership position in the world political and economic structure--a leadership role underwritten by its preeminence in advanced technology. The erosion of this preeminence has far-reaching economic, political, and national security consequences for the United States.

THE ECONOMIC HEALTH AND VITALITY OF THE AMERICAN ECONOMY DEPENDS ON HIGH TECHNOLOGY

The special combination of contributions to the U.S. economy of high-technology industries--including high productivity growth and low inflation--indicate the importance of this segment to the overall strength of the U.S. industrial base. Further, there is a direct linkage between the research activities conducted by the high-technology industries and the U.S. standard of living. Research nutures innovation, which feeds technological progress, which leads to productivity gains. Productivity over the long run is the predominate element which determines the overall ability of the U.S. economy to grow and in turn to produce a higher standard of living and new jobs.

Likewise, the composition of both the U.S. economy and U.S. trade--how much is services versus manufacturing--affects the ability of the economy to provide new jobs and an ever-improving relative standard of living. From some perspectives, the United States can afford to be indifferent about the commodity composition of its economy and exports. For example, the United States has limited control over its current account balance. Nevertheless, the crucial linkage between research and productivity necessitates that attention be paid to the structure of the U.S. industrial base. To reverse the trend of a relative deterioration of the U.S. standard of living, structural changes must occur in the U.S. economy.

As the high-technology industries of other countries have emerged as strong international competitors, U.S. high-technology industries are facing in a significantly altered competitive environment. Technological preeminence, already lost in some high-technology segments, will be increasingly difficult for American society to successfully maintain. The combined effect of the general maturing of the world economies and increased foreign government support of these sectors ensure that for the indefinite future America's leadership position will be challenged.

Reversing the current trend of a continuing erosion of U.S. technological preeminence will also require a sustained investment in research. However, the policies of foreign governments in high technology will tend to undermine the willingness and capability of U.S. firms to conduct research and development programs in areas where foreign target-industry programs are active. Thus concurrently with the increased need for the United States to invest in research and development, international pressures may aggravate the ability of U.S. firms to respond.

THE WEAKENED POSITION IN HIGH TECHNOLOGY AFFECTS U.S. NATIONAL SECURITY

A strong economic system is vital to the security of the free world. The United States has a dual role both as the principal guarantor of Western security and the leading defender of the economic system of the free world. In this context U.S. technological preeminence and high-technology industries that generate advanced know-how take on strategic importance.

The special role high-technology industries play in the nation's defense is evidenced by the fact that almost two-thirds of all hardware sales to the Department of Defense are produced by the high-technology sector. Because advanced technology products and the industries that supply and develop them form such a critical underpinning of our defense capability, there is a trade-off between additional benefits from expanded international specialization and the potential adverse consequences for U.S. national security.

- A realignment in the relative balance of power may take place with a weakened U.S. technological base.

- The pace and direction of technological advance is difficult to predict, but such advance must be recognized as vital to providing for U.S. defense strength.

- Increased reliance on foreign sources for military technology heightens U.S. vulnerability. In the area of defense-related know-how, the United States was previously relatively immune to leverage resulting from technology sharing.

- With the loss of leadership in key sectors of high technology, the United States will lose direct control over the transfer of sensitive advanced technology to the Soviet Union.

In an increasingly economically interdependent world, any effort to preserve self-sufficiency may entail economic costs. To maintain an adequate capability across a broad spectrum of advanced technologies, the United States may need to be willing to subordinate cost considerations to security considerations. Without a strong high-technology industrial base in place, defense will have to bear higher costs, in any case, to maintain U.S. independence in military-related technology. Furthermore, as demonstrated in previous conflicts, technological capabilities can decisively influence the course of events.*

Thus, the maintenance of a broad U.S. technological base that enhances the defense capabilities of the United States and its allies is a prudent element of the U.S. national security strategy.

* See Appendix F for two illustrations.