Chapter 9

The Composition of Trade

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Many of the changes occurring in U.S. trade can only be understood by examining specific sectors. Themes developed in earlier chapters, such as the rapid diffusion of information technologies, the increased importance placed on flexibility and adaptability, and the higher degree of interfirm linkage, also apply in an international context—but unlike the discussions of networks in chapters 3 and 6, the present chapter is limited to a brief analysis of production sectors heavily involved in international trade. These include:

- semiconductors,
- drugs and medical supplies,
- autos,
- textiles and apparel,
- machine tools,
- agriculture,
- energy,
- construction,
- business services, and
- computer software.

Among other things, the discussion covers the "export" portion of final demand (see figure 1-4 of ch. 1).

MANUFACTURING

High-Technology Trade

The variety of existing definitions of "technology intensive" has led to confusion and contradictory results in analyses of the position of U.S. producers in export markets. Part of the dilemma involves the curious combination of processes associated with the high-technology industry. "High technology" can range from advanced research and development facilities, product development, or marketing to relatively primitive manufacturing operations. Indeed, assembly of the most sophisticated computer or telecommunications device may involve a production process virtually identical to the one traditionally used to produce garments, and skill levels of the employees involved are often roughly equivalent.[1] Therefore, while part of the enterprise may draw an advantage from an ability to use technology effectively, part of the work may depend on the availability of inexpensive labor.

Much of the production of high-technology goods has become a global operation, with components shipped to a variety of different countries before final assembly-leaving a complex trail of value-added around the world. Moreover, different countries have established very different strategies for producing high-technology goods. For example, U.S. producers have taken advantage of low-wage foreign assembly of semiconductors: in 1983, nearly 80 percent of U.S. circuits were assembled abroad. The Japanese, however, have kept manufacturing close to their design facilities, and assemble 90 percent of their circuits at home.[2] The complexity of this situation makes it difficult to assess accurately differences in national comparative advantage.

Decisions about whether or not to produce a technology-intensive product in the United States depend on complex factors, few of which are easy to include in an assessment of comparative advantage. While some high-technology products (such as generic drugs or semiconductor memory chips) lend themselves to economies of scale and mass production, others (such as application-specific semiconductors and private branch exchange (PBX) systems) require close contact and coordination with a customer. Furthermore, many high-technology goods (particularly pharmaceuticals) are produced offshore to avoid U.S. regulations or trade restrictions.

[1] M. Fernandez-Kelly, *For We Are Sold, land My People: Women and Industy in Mexico's Frontier* (Albany, NY: State University Press, 1983). See p. 310 for definitions of "high technology."

[2] Charles Ferguson, "American Microelectronics in Decline: Evidence, Analysis and Alternatives," paper prepared at the Massachusetts Institute of Technology, Cambridge, MA, November 1985.

The United States still commands a much larger share of world technology-intensive exports than any other nation. The Organization for Economic Cooperation and Development (OECD) estimated that in 1982, only three countries—Japan, Britain, and the United States—had an overall comparative advantage in "high R&D intensive industries" (aerospace, office machines, electronics and components, drugs, instruments, and electrical machinery); and only four—the United States, Japan, Germany, and Canada—in "medium R&D intensive industries" (autos, chemicals, non-electrical machinery, rubber& plastics, and non-ferrous metals).

However, the United States lost market share in all products except computers and consumer electronics between 1970 and 1980. Of the 10 high-technology products considered,[3] the United States lost market share in 8 while Japan gained in 10. The overall pattern is striking: U.S. losses are almost perfectly mirrored by Japanese gains.

Between 1965 and 1982, U.S. exports of ten broad product categories grew only slightly more slowly than those of all of the other large suppliers (the 14 largest OECD countries), with the exception of Japan. Japan's high-technology exports grew by an average of 21.9 percent per year during this period, compared to 15.5 percent for the United States and 16.1 percent for all other countries taken as a group.[5] Since 1965, Japan's share of all high-technology exports has more than doubled, from 7.2 percent in 1965 to 17.3 percent in 1982.

By the OECD's measure, however, the "erosion" of U.S. comparative advantage in these industries has been slight. In the high R&D intensive industries, the comparative advantage of three countries—the United Kingdom, France, and Japan—increased during 1970-83; Japan also "shed" its advantage in low R&D intensive industries most rapidly. The comparative advantage of the Netherlands, Sweden, and particularly Germany increased in the medium R&D intensive category.

An examination of imports (see table 9-l), however, reveals strikingly different patterns. Japanese import penetration, low in all areas of manufacturing, increased only slightly during 1970-80. At the beginning of the period imports were low in the United States, as in Japan. But import penetration increased rapidly in the United States. Between 1974 and 1981, U.S. high-technology imports grew nearly twice as fast as output for domestic consumption.[6]

3 U.S. Department of commerce, "An Assessment of U.S. Competitiveness in High Technology Industries," Washington, DC, 1983, pp. 44-45. The product groups considered are drugs & medicines, business machines & equipment, computers, electrical and electronic machines & equipment, telecommunications equipment, electronic components, consumer electronics, jet engines, aircraft, and scientific instruments.

4 Guided missiles; communications equipment and electronic components; aircraft & parts; office, computing, & accounting machines; ordnance; drugs & medicines; industrial organic chemicals; scientific instruments; engines, turbines & parts; and plastic materials, synthetic resins, rubber & fibers.

5 Victoria Hatter, "U.S. High Technology Trade and Competitiveness, " Office of Trade and Investment Analysis, International Trade Administration, U.S. Department of Commerce, Washington, DC, 1985.

6 Lester Davis, "New Definition of 'High Tech' Reveals That U.S. Competitiveness in This Area Has Been Declining," Business America, vol. 5, No. 2, Oct. 18, 1982.

Table 9-1 .—Rates of Import Penetration for Manufacturing: International Comparisons

	High R&D - intensive industries			Medium R&D - intensive industries			Low R&D - intensive industries		
Country	1970	1975	1980	1970	1975	1960	1970	1975	1980
United States	4.8	7.7	14.3	7.0	8.9	11.2	4.8	5.7	6.1
Japan	6.6	6.4	7.9	5.5	5.0	6.9	3.5	4.4	5.4
Germany	21.6	28.4	42.5	22.8	27.4	33.4	16.8	21.6	27.4
France	23.1	23.3	28.8	23.7	26.0	31.6	11,8	14.7	17.7
United Kingdom	18.6	31.2	44.2	22.0	29.3	43.1	13.4	17.4	18.4
Italy	18.3	25.3	33.4	23.8	27.7	41.8	11.9	17.8	25.4
Canada	42.6	45.7	58.0	58.5	59.2	59.2	12.7	14.1	13.8
Australia	42.2	39.7	43.1	30.6	30.4	32.5	14.2	14.8	18.5
Netherlands	71.0	67.8	69.8	80.5	79.3	85.6	38.3	43.4	51.0
Sweden	44.9	46.1	54.6	44.4	48.1	53.5	23.1	27.2	28.3
Belgium	75.7	87.3	N.A.	88.0	86.3	N.A.	40.3	48,8	64.0

NA = Not available.

SOURCE: Organization for Economic Cooperation and Development, *OECD Science and Technology Indicators* II *Resources Devoted to R&D, Technological Performance and Industrial Competitiveness* and *Annex, 1985.*

Japanese high-technology imports from the United States have, however, also grown rapidly in the past few years, increasing 42 percent during 1982-86.[7]

Japanese trade in semiconductors is shown in table 9-2. While the Japanese share of both U.S. and *world* markets grew substantially during 1982-85, more than 90 percent of Japanese demand for these products was met by Japanese suppliers at a higher-than-market price. Indeed, many of the Japanese firms that produce semiconductors (Hitachi, Toshiba, Fujitsu, and NEC) were also major consumers of these devices, and the higher costs were absorbed because management was willing to undertake a long-term development program.[8]

Another analysis of U.S. performance indicates that since 1962 the U.S. world market share has declined in 10 out of 17 technology-intensive sectors, though in four of them—telecommunications apparatus, medicinal & pharmaceutical products, scientific, medical & controlling instruments, and plastics—shares seem to have stabilized or improved slightly between 1977 and 1982.[9] While its international trading position in aircraft has declined, the United States still holds a commanding 45 percent of the world market. Market share in 2 of these 10 products—office machines and photographic supplies—has declined only slightly.

A set of case studies suggests that U.S. firms continue to perform relatively poorly in areas such as semiconductor memory chips, telephone hand-sets, and generic drugs, where comparative advantage depends primarily on price, while the Nation continues to do well in areas such as application-specific semiconductors, advanced telecommunication systems, and biotechnologies-all of which require careful coordination with the consumer. The characteristics of these specialized markets often require that production facilities be located close to customers because it is necessary to adapt new products to shifting consumer needs.

The extent to which this U.S. advantage could be challenged by skillful foreign producers is largely unknown. There is reason to believe that markets for specialty products will increase as both industrial and individual customers begin to appreciate the flexibility inherent in new production technology. This would seem to benefit U.S. producers. On the other hand, the Japanese have proven successful at entering specialty markets and exploiting flexible chip production systems. They have, for example, established 25 to 50 design centers for semiconductors around the world.[10] Relatively standardized products can be made at a central location and adapted through software or site assembly to fit a variety of different applications. Both of these effects would appear to work to the disadvantage of U.S. firms incapable of competing in the production of the basic good. Some of the value-added would, of course, still remain in the United States, although not necessarily in the hands of a U.S.-owned firm.

Semiconductors

The dramatic reversal of the U.S. role in the open market for "merchant" semiconductor manufacturing is symptomatic of the problems the United States is facing.[11] The United States is in grave danger of

[7] William Finan, Perry Quick, and Karen Sandberg, "The U.S. Trade Position in High Technology: 1980-1986," report prepared for the U.S. Congress, Joint Economic Committee, Washington, DC, October 1986, pp. 10-12.

[8] C. Ferguson, op. cit., footnote 2.

[9] Michael Aho and Howard Rosen, "Trends in Technology Intensive Trade: With Special Reference to U.S. Competitiveness," Bureau of International Labor Affairs, U.S. Department of Labor, 1980; and United Nations, *Statistical Yearbook:* 198,?, New York, NY, 1984.

[10] C. Ferguson, op. cit., footnote 2.

[11] See further discussion of competitiveness in this and other industries in N. Bruce Hannay, "Technology and Trade: A Study of U.S. Competitiveness in Seven Industries," in R. Landau and N. Rosenburg, *The Positive Sum* Strategy (Washington, DC: National Academy Press, 1986).

Table 9-2.—Japanese Semiconductor Market Shares by Region

Year	North America	Western Europe	Japan	Rest of world	Total
1982	11	7	90	31	33
1983	13	8	91	33	37
1984	16	10	91	34	38
1985	18	11	92	35	40

SOURCE: Charles Ferguson, "American Microelectronics in Decline: Evidence, Analysis, and Alternatives," Massachusetts Institute of Technology, Cambridge, MA, November 1985; based on data from Smith Barney, Dataquest, Semiconductor Industry Association, and The New *York Times.*

losing its leadership in both the design and the production of semiconductors sold on the open market. On the other hand, the sharp decline in the labor content of semiconductors, and the increasing need to tailor semiconductors and products associated with them to specific markets, seems to indicate that competitive position in this area will increasingly depend on skills in managing and marketing technology rather than on low wages.

Loss of U.S. leadership may be partly due to changes in the structure of the industry: where relatively small, entrepreneurial firms funded by venture capital used to enjoy profitable operations in well-defined market niches, the industry now requires the management skills, capital resources, and patience of a major firm. Major Japanese firms entering the semiconductor business were able to provide such resources, while small U.S. firms had difficulty expanding.

Both the development and production costs of semiconductors have grown explosively. The 32-bit microprocessor chips now entering the market will sell for as little as $100, but are as powerful as the large mainframe computers operating a decade ago. Their development was a major undertaking, requiring a complex network of computer-assisted design and simulation equipment that cost at least $50 million. A semiconductor manufacturing facility could be purchased for $2 million in 1975, while a state-of-the art facility for producing a "very large-scale" integrated semiconductor device today may cost up to $200 million. Components of the manufacturing process have themselves become extraordinarily complex and expensive. Masking units that cost $2 million for the semiconductors of the late 1970s cost $15 million for 256k-chip production in the mid 1980s. Optical systems that once cost up to ***$300,000*** have been replaced by computer-driven electron-beam devices capable of sub-micron resolution costing $3 to $4 million.

The severe reduction in world demand for semiconductors in 1985 (sales were down by 18 percent) increased the problems of U.S. producers. Large Japanese firms maintained market share while U.S. producers suffered 25 to 60 percent losses.[12] Many smaller firms were forced to sell technology to competitors, including the Japanese.

12 C. Ferguson, **op. cit.,** footnote 2.

Various factors have been responsible for the emergence of the Japanese semiconductor industry:

- a capacity for effective reverse engineering;
- a management system capable of coordinating large, expensive, and technologically sophisticated development and production operations;
- a strong focus on specialized, high-volume products; and
- a national program that successfully blocked imports during a critical period of the industry's development.

The dramatic progress of Japanese skills in this area is highlighted in table 9-3. The Japanese captured only a small share of the semiconductor market in the 1970s, but dominated semiconductor production by the 1980s.

The Japanese have also begun to challenge U.S. producers in the initial design of advanced memory units, and even of the more sophisticated microprocessor units. In what maybe a classic case, Hitachi has become Motorola's second source producer of its MC68000 chip. And using an improved semiconductor technology (CMOS), Motorola is now a second source producer for Hitachi's chip. The large Japanese firms are also challenging U.S. producers in the development of the 32-bit processors that represent today's state of the art. The Japanese are expected to have a virtual world monopoly on one-million bit memory units available in open markets (IBM and AT&T have proprietary designs not sold on the open market, in part because of antitrust considerations).

The strategy giving the Japanese this lead has also propelled them into a leading position in equipment

Table 9-3.—Japanese Share of World Markets in Random Access Semiconductor Memories

	Integration level (thousands of bits/chip)	Japanese share of world markets (percent)
1970	1	0
1974	4	5
1978	16	40
1982	64	70
1985	256	85
1987 (est.) . . .	1,000	90

SOURCE: Charles Ferguson, "American Microelectronics in Decline: Evidence, Analysis, and Alternatives," Massachusetts Institute of Technology, Cambridge, MA, November 1985, baaed on data from Dataquest, Hambrecht & Quist, and the Semiconductor Industry Association.

designed to produce advanced semiconductors. Devices for optical masking at megabit levels are sold by four Japanese companies and one U.S. company, Teradyne, which is struggling to maintain its market position. Three of the Japanese firms are owned by semiconductor producers (Fujitsu, NEC, and Hitachi).

U.S. losses to Japanese producers in these areas were not primarily due to unique Japanese access to materials or labor, but owed much to trade policies, dynamic management, and marketing strategies designed to capture the benefits of economies of scale. The strategy succeeded primarily because of Japanese ability to learn rapidly and continuously, at first through acquisition of U.S. technology in open purchases and reverse engineering and more recently through independent innovation.

Telecommunications

Like semiconductors, telecommunications equipment is a curious amalgam of mass produced, commodity-type products, such as telephone handsets that compete primarily on the basis of price, and highly sophisticated, specialized products requiring close interaction with customers during initial installation and servicing. U.S. producers have virtually abandoned the commodity market to low-wage nations. AT&T ceased domestic production because it could not compete with low-wage production from overseas despite the low labor content of hand-sets.

The shifting value of the dollar, especially in comparison to the yen, may be changing this calculus. Tokyo-based Fujitsu has begun to export celluar car phones, modems, and computer disk drives from its plant in Texas because the labor and overhead rates per hour are lower than those in Nasu, Japan.[13]

U.S. producers continue to enjoy a significant share of domestic business telephone equipment markets, particularly PBX and large telephone-switching equipment. U.S. production of satellite systems, fiber-optic, and other major components of telecommunications systems remains quite competitive, although the Japanese challenge in optical transmission is growing.

A key question is to what extent do advanced telephone and communications systems resemble consumer electronics commodities, and to what extent do they resemble highly specialized, application-specific devices requiring a strong local manufacturing capability? Even advanced telecommunication products may soon be made overseas. The astonishing power of low-cost microprocessors and memory units makes it possible to develop generic products that can be cheaply tailored to meet a variety of purposes. Because of this, there is no guarantee that U.S. producers can continue to enjoy even the specialty end of telecommunications markets.

The U.S. position is heavily influenced by the fact that most large telecommunication systems abroad are owned and operated by governmental or quasi-governmental concerns that discourage foreign purchasing. Japan recently sold half the shares of the Nippon Telephone and Telegraph system to private owners, but foreign purchases have not been large. The United States has elected to open its markets to foreign sales without insisting on the right to sell into other public systems.

Drugs and Medical Devices

U.S. pharmaceutical manufacturers rely on international sales for a significant portion of their income. In 1982, 41 percent of total sales were to foreign countries, compared to 30 percent in 1967. But foreign firms are beginning to encroach on U.S. markets rapidly and U.S. firms are increasingly producing overseas. The position of U.S. firms is threatened in part by a gap in research investment. Japanese and European companies are spending about 11 percent of each sales dollar on research, compared with about 7 percent for U.S. manufacturers.[14]

In a survey of large pharmaceutical firms, interviewees noted that the decision to locate abroad is driven predominantly by the need to reduce innovation costs and gain market shares. In a few cases, manufacturing abroad is required by local import laws that make it impossible to market a drug unless it is produced within that country's borders, Firms also locate outside the United States for tax reasons. Since pharmaceutical plants are highly automated, whether located in the United States or abroad, cheaper labor does not play a large role. An

[13] " For First Time, Fujitsu Exports Gear Made in U. S.A.," *Communications Week,* Feb. 15, 1988, p. 34.

14 Standard and Poor's Industry Surveys, *Health Care, Sept. 1, 1983.*

example of the movement abroad is illustrated by the fact that in 1980, two major U.S. drug companies introduced 94 products world-wide—of which only 11 were manufactured in the United States.[15]

Foreign trade is also an important source of income for the U.S. medical devices industry. In 1984, exports—which accounted for about 12 percent of industry shipments—exceeded imports by nearly two-thirds. Even so, U.S. trade surpluses have begun to decline. Historically, the United States has a net trading deficit in medical devices with only one of its major trading partners, West Germany. However, in recent years Japan's medical exports to the United States have grown much faster than U.S. exports to Japan, and the United States has now incurred a trade deficit with Japan in this area.[16]

Other Manufacturing

Competition in manufacturing fields outside of "high-technology" sectors (examined here are autos, textiles and apparel, and machine tools) also depends on sophisticated technology, although often in a less visible way. Sophisticated production technology is needed to compete in an economy where energy prices, the value of the dollar, costs of critical materials, and a variety of other factors can change rapidly and unpredictably. The ability to track progress in both products and production processes is becoming a key to survival in fields as diverse as apparel assembly and auto manufacturing.

Autos

The auto industry has been a dominating force in the U.S. economy for more than 50 years. The industry is heavily linked to other parts of the economy. In recent years these links have extended to include advanced electronics and materials, used both in autos produced and in production equipment. In 1960, the United States produced half the world's autos. Today Japan is close to that figure. The United States imported 38 percent of all autos sold in 1986.[17]

Foreign sourcing of auto parts has recently become increasingly common. The suppliers of the imported components or finished vehicles may be partly or fully owned by the importing U.S. manufacturer (see table 9-4), or may be unrelated in terms of equity holdings—a process known as "out-sourcing." Of the

Table 9-4.—Major U.S. and Foreign Equity Holdings in Auto Firms, 1987

U.S. ownership of foreign firms:

American Motors Corp.
49% of Arab American Vehicles Ltd., Egypt
31% of Beijing Automobile Works, China

Chrysler
50% of Diamond-Star Motors Corp., USA with Mitsubishi
24% of Mitsubishi Motors Corp., Japan
16% of Maserati S.P.A., Italy

Ford Motor Co.
70% of Ford Lio Motor Co., Taiwan
25% of Mazda Motor Corp., Japan
48% of Iveco-Ford Truck Ltd., Great Britain (with Fiat)
10% of Kia Motors Corp., South Korea
42% of South African Motor Corp., South Africa
30% of AMIN Holdings, Malaysia
30% of Otomobile Sanayi Anomin Sirketi, Turkey

General Motors Corp.
50% of Daewoo Motor Co., Ltd, S. Korea
39% of Isuzu Motors Ltd., Japan
24% of Volvo GM Heavy Truck Corp., USA with Volvo
5% of Suzuki Motor Corp., Japan
50% of New United Motor Manufacturing, USA with Toyota
49% of General Motors Kenya Ltd., Kenya
49% of Constructor Venezolana de Vehiculos, Venezuela
46% of Autos y Maquinas del Ecuador
31% of General Motors Egypt S.A.E
22% of omnibus BB Transported S. A., Ecuador
20% of Industries Mecaniques Maghrebines S. A., Tunisia

Foreign ownership of U.S. firms:

Japan
Fuji Heavy Industries Ltd.: 49% of Subaru-Isuzu Automotive Inc., USA
Isuzu Motors Corp.: 51% of Subaru-Isuzu Automotive Inc., USA
Mitsubishi Motors Corp.: 50% of Diamond-Star Motors Corp, USA
Toyota Motor Corp.: 50% of New United Motor Manufacturing Inc., USA

Europe
Renault: 42% of Mack Trucks Inc., USA

SOURCE: *Automotive News, 1987* Market Data Book Issue.

[15] Results of interviews with executives of several major pharmaceutical firms conducted for the Office of Technology Assessment by the Conservation for Human Resources, Columbia University, New York, NY.
[16] U.S. Department of Commerce, Bureau of Industrial Economics, *U.S. Industrial Outlook, 1987* (Washington, DC: U.S. Government Printing Office, 1987).
[17] U.S. Department of commerce, Bureau of Economic Anal@, "National Income and Product Accounts," *Survey of Current Business, vol. 67, No. 6,* July 1987, Table 1.17.

big three, Chrysler is the leading out-sourcer. In terms of value, about 70 percent of the components of Chrysler's vehicles are manufactured by outside suppliers.[18] Auto makers also supply their U.S. auto assembly plants with components produced by their own foreign plants. In addition, each of the big three imports at least one foreign-made vehicle and resells it under a domestic brand name.

Experiences are mixed. Some changes (such as lighter materials and electronic controls) have been introduced, but more innovation is needed. A comparison with the Japanese auto industry suggests that more changes in organization, management, and labor relations will be required.[19] U.S. firms have taken major steps to restructure domestic production, and have entered joint ownership arrangements with Japanese firms.

Textiles and Apparel[20]

Textiles and apparel imports have risen sharply, leading to a 1986 deficit of over $21 billion. This is 4.5 times higher than the 1980 deficit (in current dollars). Trade growth was particularly rapid in areas where a significant amount of hand labor is required (a significant part of the apparel market) while U.S. producers maintained share in areas where highly automated processes keep labor costs low.

The introduction of a "quick response" system, which holds inventories low and avoids overstocking, could do much to help U.S. producers compete with low-wage nations simply by virtue of significantly reduced inventories. However, this will require major changes in how information flows between the different components in the production and retail chain.

Virtually all textile production technology is currently being imported, and producers of textile machinery and apparel assembly machinery conduct virtually no research. U.S. textile machinery manufacturers that dominated the global market for looms in 1960 now make *none* of the widely used, advanced programmable/shuttleless looms that can increase output by 200 to 300 percent. In 1983, more than 90 percent of U.S. textile equipment production was of replacement parts for old U.S.-made looms.

The single major investment in advanced apparel production in the past decade involved a joint project between industry, labor, and the U.S. Government. The project, known as the Textile/Clothing Technology Corporation (TC)[2], spearheads the U.S. effort in automated sewing. Thus far, it has succeeded in automating the production of sleeves for men's suits. Industry and organized labor are providing approximately $5 million a year for these and related efforts, and the Federal Government has pledged $3 million. This amount could be much greater; Japan is spending $80 million to develop a fully automated apparel process for the 21st century. While TC[2] is an effort to automate sewing production, the Japanese effort is state-led industrial restructuring on a large scale.

Machine Tools

It is somewhat ironic that the basic tools of mass production cannot themselves be mass produced. Of total world machine tool production, 75 percent is produced in relatively small batches, and 85 percent of all batches have fewer than 50 parts.[21] Small batch production and the need for careful integration of the design, installation, and operation of sophisticated machine tool systems would appear to give domestic producers a natural competitive advantage. In fact, foreign producers—particularly those in Japan and West Germany—have made major inroads into U.S. markets. In 1985, the United States imported 41 percent of its machine tools-nearly half from Japan, and about 14 percent from West Germany.

A quota on machine tool imports took effect January 1, 1987. It applied to Japan, Taiwan, West Germany, and Switzerland, limiting their shipments to the United States for 5 years. These temporary restraints were ordered on national security grounds

18 Kevin Flaherty, "Foreign Sourcing by the U.S. Automobile Industry," report prepared for the U.S. Congressional Research Service, Washington, DC, Nov. 8, 1985.

19 W.J. Hampton and J. I?. Not-man, "General Motors: What Went Wrong?" Mar. 16, 1987, p. 102.

20 This section is drawn from U.S. Congress, Office of Technology Assessment, *The U.S. Textile and Apparel Industry: A Revolution in Progress–Special Report, OTA-TET-332* (Washington, DC: US. Government Printing Office, April 1987).

21 U.S. Department of Commerce, International Trade Administration, "A Competitive Assessment of the U.S. Flexible Manufacturing Systems Industry," July 1985, p. 8.

so as to give domestic producers time to modernize. Domestic producers could gain a 20 percent market share from the quota for Japan alone.[22]

Since much of the equipment marketed by Japanese firms was developed internally by firms that needed the equipment for their own production, the Japanese enjoy a good international reputation for bringing equipment to a plant that works as advertised and performs comparatively reliably. This gives them a considerable advantage in overcoming producers' reluctance to invest in equipment fraught with many unknowns.

In part because of an overt government program to improve metal fabrication, Japan is the largest producer of machine tools and robots in the world. In 1984, Japan exported more than one-third of the machine tools it made and imported only 3.4 percent of its consumption. Most of the industry's production is relatively small in scale—81 percent of the firms employ fewer than 20 workers. Nonetheless, a growing fraction of the production is moving to South Korea, Singapore, and Taiwan, as well as to licensed manufacturers in the United States, the United Kingdom, West Germany, and Belgium.[23] In 1982, Japanese producers were using about 31,000 robots-virtually all domestically produced, while the United States, with nearly twice as much gross output, used only about 7,000.

In terms of price and performance, U.S. machine tools have a somewhat mixed record in international markets. Imports have gained a solid position in the U.S. market. U.S. and European (West German, Italian, and French in particular) producers enjoy a good reputation in highly sophisticated machine tools designed for specialized applications such as heavy cutting, and in systems that require a considerable amount of software design. U.S. producers of advanced equipment appear to have a strong advantage in the fabrication of military equipment, but much of this equipment is so highly specialized and sophisticated that it does not transfer easily into a cost-conscious commercial market.[24] The Japanese enjoy a reputation for high-quality, small-and medium-sized machining centers that are durable, simple, and flexible.[25]

[22] *The Washington Post,* Dec. 17', 1986, P. 4

[23] "A Competitive Assessment of the U.S. Flexible Manufacturing Systems Industry," op. cit., footnote 21, p. 32.

[24] 1 bid., p. 81.

[25] Ibid.

NATURAL RESOURCES

While the petroleum crises of 1972/73 and 1979 forced the United States to recognize its dependence on foreign resources, the United States has suffered a trade deficit in raw materials for some time. In 1985, food, raw materials, and fuels constituted 24 percent of U.S. exports and 27 percent of U.S. imports, resulting in a net deficit of $45 billion. But many resource-intensive U.S. industries actually gained ground in comparison with other sectors of the economy.

This occurred partly because many of the Nation's major trading partners are much more poorly endowed with resources. On average, food, raw materials, and energy represented 40 percent of the imports of the seven largest free economies (75 percent of Japan's imports) in 1984, and 20 percent of their exports (2 percent of Japan's exports). Most European nations, and certainly Japan, rely on manufacturing exports to cover large trade deficits in resources.[26] Indeed, it is possible that Japan's enormous trade surplus occurred partly because Japan was positioning itself to pay large fuel import bills—bills that fortuitously did not need to be paid because oil prices fell.

Agriculture

The United States enjoyed enormous growth in net exports of agricultural products during the late 1970s and early 1980s, but the trade surplus has been eroded in recent years. U.S. exports of bulk commodities (primarily wheat, corn, and soybeans) have fallen sharply while imports of high-value products (fruits, vegetables, and meats) continue to increase. Ironically, the United States has never done well in capturing a large fraction of the value of world

[26] Directorate of Intelligence, Handbook Of *Economic* Statistics, 1986 (Washington, DC: U.S. Government Printing Office, 1986).

food trade; rather, the Nation has done well in producing large volumes of commodities. In 1984, the United States had 34 percent of the *volume* of world trade in food and food products but only 13 percent of the *value* of these products. The United States has been a net importer of processed food since 1983.[27]

The export boom of the late 1970s was driven by a rapid increase in world demand for imported food made possible by economic growth in developing nations, the entry of China into world markets, and continued crop failures in the USSR. U.S. farmers were in a unique position to exploit these developments because they had large stocks in storage and could also expand production rapidly. During the early 1970s, harvested wheat acreage in the United States rose by an amount greater than the total harvested by Canada during that period.[28]

But conditions changed rapidly after 1980. A global recession meant that many developing nations lacked the resources to purchase imported foods. Many nations, particularly in the European Economic Community (EEC), rapidly increased production to enjoy a share of expanding world markets. The rising value of the U.S. dollar helped many nations enter world markets, and once there they were reluctant to abandon their market shares when world demand decreased and the value of the dollar fell. Many maintained shares by providing export subsidies for their farmers. Many developing nations with heavy debt burdens have been encouraged by the World Bank, the International Monetary Fund, and U.S. banks to increase exports of agricultural products in order to earn the foreign currency needed to repay their debts.

Technology transfer played a key role in these events. The U.S. farm community no longer enjoys a clear lead in agricultural technologies, partly because U.S. multinational corporations have successfully marketed new products abroad. Between 1959 and 1980, global expenditures on public agricultural research increased by 360 percent in real terms, and the number of scientists committed to agricultural research tripled. The North American share of this research spending fell from 37 to 23 percent during the period, while research spending in Latin America and Asia increased six-fold. The United States did contribute heavily to the growth in world research capabilities—but nearly 30 percent of all students receiving PhDs in agriculture and home economics in the United States between 1975 and 1979 were foreign, as were more than 43 percent of those who received degrees in agronomy, soils, and soil science.[29]

The rapid equilibration of world agricultural technology has, of course, had enormous benefits. The "Green Revolution" enabled many nations to feed themselves better, reducing demand for imports and eroding the comparative advantage of large U.S. farming regions. Many of the emerging technologies will have a relatively greater influence on the production costs in regions with poor resources than in well-developed regions. While it is difficult to obtain accurate estimates of differences in real production costs around the world, it appears that many basic agricultural commodities can now be produced at a lower cost outside the United States.

It is clear that the U.S. agricultural community, once dominant in feeding the world, will need to work much harder to maintain a trade surplus in the future.

Energy

Petroleum has dominated U.S. resource trade for a decade. Energy imports climbed to one-third of all U.S. imports (half of Japan's imports) in 1981, but have fallen sharply as a result of the collapse of the Organization of Petroleum Exporting Countries (OPEC) cartel, reduced U.S. energy demand, achievements in diversification of energy inputs in the U.S. economy, and significant efforts to find substitutes for petroleum. Should these efforts for finding substitutes for petroleum slacken, however, fuel imports are likely to increase steadily in the future.

U.S. petroleum production is likely to decline 10 to 30 percent by the turn of the century and more sharply after that. The U.S. Department of Energy's

[27] Penelope Cate, "Upcoming World Trade Talks: What's at Stake for U.S. Agriculture," *Congressional Research Service Review,* vol. 7, No. 8, September 1986, pp. 2-5, 26-27.

[28] U.S. Congress, Office of Technology Assessment, A Review of U.S. *Competitiveness* in Agricultural Trade—A Technical Memorandum, OTA-TM-TET-29 (Washington, DC: U.S. Government Printing Office, October 1986).

[29] Robert E. Evanson, J. Putnam, and Cad pray, "The Potential fOr Transfer of U.S. Agricultural Technology," contract report prepared for the Office of Technology Assessment, 1985.

(DOE) "revised reference case" shows indigenous production declining 42 percent between 1985 and 2010.[30] If U.S. energy demand follows the DOE forecast, U.S. imports of petroleum (measured in barrels) will increase 225 percent by 2005 and 240 percent by 2010.

Overall world demand for imported fuels will increase if the DOE forecasts are correct, and demand for oil by developing nations will increase as a result of economic growth and development. World supplies, however, will shrink as output from the fields m the United States, the North Sea, and the Soviet Union begins to decline near the turn of the century. Arab OPEC countries, particularly Saudi Arabia, will then dominate world exports even more than they do currently. It is extremely difficult to forecast the effect of these developments on world prices, but the United States will need to find a way either to pay for substantially rising oil imports during the next 20 years or to reduce demand for petroleum through greater energy efficiency and/or alternative fuels.

Efficiency in automobile travel will be a key issue. Unfortunately, the Japanese and other producers appear better prepared to move highly efficient automobiles (and other energy-efficient products) to the market than U.S. manufacturers. An international event that resulted in a sharp increase in world oil prices would almost certainly leave foreign producers in a better position to meet world demand for efficient vehicles than U.S. firms.

30 U.S. Department of Energy, Office of Policy Planning and Analysis, "National Energy Policy Plan Projections to 2010," Washington, DC, June 1987, table 3-10.

Other Raw Materials

In addition to more efficient use of energy, new technologies could change demand for other kinds of raw materials.[31] New materials are likely to become competitive as substitutes for traditional ferrous and non-ferrous metals. Potentially vulnerable industries include copper, for which fiber optics and superconductors are substitutes; aluminum, for which ceramics and carbon fiber composites might substitute; and steel sheet, which could over time see competition from superpolymers used to produce light corrosion resistant shells for autos, aircraft, and large storage containers.[32]

Material demand will be further reduced by designing products such as automobiles for longer life expectancies, and through recycling. Demand for raw materials such as steel, chemicals, paper, cement, and aluminum represents a shrinking share of the economies of most developed nations.[33]

31 See U.S. Congress, Office of Technology Assessment, Advanced *Materials by Design,* Washington, DC, forthcoming.

32 Harald Malmgren, "Technological Change and Trade Policy," Trade Department of the Ministry of Foreign Affairs, Sweden, in *New Technologies and World Trade: Proceedings of a Symposium in Stockholm,* Stockholm, Sweden, June 5-6, 1984.

33 Eric Larson, Marc Ross, and Robert Williams, "Beyond the Era of Materials," *Scientific American, vol. 254, No. 6,* June 1986, p. 34.

CONSTRUCTION

The U.S. construction industry is being integrated rapidly into world markets. U.S. heavy construction firms, and architecture and engineering businesses, have played a major role in world markets since the end of World War II. They now face strong competition, particularly from Asian countries. Even U.S. residential construction firms must now compete with foreign producers, as appliances, building components (ranging from kitchen cabinets to door knobs), hand tools, and even entire housing units are being imported.[34]

Although foreign construction contracts were gained by just 60 of the 400 largest U.S. contractors in 1985 (accounting for 21 percent of total contract awards),[35] the United States stood at the forefront of this expanding world market as recently as 1972. The oil boom of the 1970s increased demand for construction in OPEC countries, which spent substantial sums building highways, ports, and other additions to their infrastructures. While the volume of U.S. exports rose to meet this developing market, the U.S. share of world trade in construction held

34 U.S. Congress, Office of Technology Assessment, *Technology, Trade, and the U.S. Residential Construction Industry-Special Report,* OTA-TET-315 (Washington, DC: Government Printing Office, September 1986).

35 U.S. Congress, Office of Technology Assessment, *International Competition in Services,* OTA-ITE-328 (Washington, DC: U.S. Government Printing Office, July 1987), p. 124.

steady as competing industrial nations also increased their exports.

The world market for structures became increasingly competitive in the 1980s. Several factors have contributed to this, including deteriorating economic conditions and the maturation of construction firms in the developing world, penetration of international markets by construction firms from nations such as South Korea and Brazil, and policies of foreign governments to subsidize construction exports.

Moreover, foreign firms have begun to enter the U.S. market. Both the number and the earnings of foreign firms that have been awarded U.S. contracts have grown dramatically. The number of foreign firms with U.S. affiliates has also continued to increase.

TRADE IN SERVICES

The poor U.S. performance in merchandise trade in recent years has been partially offset by trade surpluses in services. Two main components of trade in services can be distinguished: income from foreign investments, and other services covering a wide range of activities such as business services, banking, insurance, construction, consulting, information, and travel.

Data on income from foreign investment are believed to be fairly accurate, but trade in "services" other than factor income is a notoriously difficult field to analyze since much of the value goes unmeasured.[36] According to the official accounts, for example, income from services other than factor income offsets less than 3 percent of the merchandise trade deficit. OTA estimates, however, imply a 16 percent offset (see table 9-5). A trade surplus in construction, consulting, engineering, technology, health, and a menagerie of miscellaneous activities cataloged as services (including income from international organizations in the United States) offset a $7 billion trade deficit in travel and transportation in 1984.

The difficulties encountered in developing international agreements about trade in services are even more complex than those encountered in trade in products. Services can raise issues of national security (nations want control over their own communication system), "cultural pollution" (there is concern about the effects of imported television programming), and different national standards of privacy (compared with some Scandinavian nations, the United States tends to be more concerned about permitting government access to personal information and less concerned about corporate access). The communications and broadcasting industries in many nations are under direct state control. In virtually all nations (the United States being no exception), trade policy in services requires coordination with regulatory agencies in areas like banking, communications, or utilities.

Business Services

The net US. trade balance in business services was negligible in 1984. There was a significant trade deficit in the most technologically demanding of these services-telecommunications and data processing—offset by a trade surplus in areas such as banking, insurance, and selling franchises for McDonald's and other firms.

International financial and banking services have grown more than 20 percent per year for the past 20 years, and the United States has been a leader in this field. U.S. financial service firms have been aggressive, innovative, and efficient—qualities that have enabled them to maintain their international position in an increasingly deregulated and competitive global environment.

Innovations in financial service products, and in the technology for delivering services, have helped U.S. banks maintain their ability to compete in international markets.[37] Indeed, U.S. firms have dominated markets for new products and financial services.

Although foreign banks have increased their presence in the United States significantly in recent years, the United States still enjoyed a trade surplus of more than $1 billion in banking in 1984. Conflicting local ordinances and long-established national

[36] U.S. Congress, Office of Technology Assessment, *Trade in Services: Exports and Foreign Revenues–Special Report, OTA-ITE-316* (Washington, DC: U.S. Government Printing Office, September 1986).

[37] *Trade in Services: Exports and Foreign Revenues—Special Report,* op. cit., footnote 34.

Table 9.5.—Trade in Services, 1984 (billions of doiiars)

Industry	(1) Exports	(2) imports	(l)-(2) Balance
Business services	**$18.9**	**$18.9**	$0.1
Accounting	0.4	0.0	0.4
Leasing	0.7	0.5	0.2
Legal	1.0	0.5	0.5
Telecommunications	1.3	2.4	(1.1)
Advertising	0.3	0.0	0.3
Data processing	0.7	2.0	(14)
Insurance	8.0	8.6	(0.6)
Investment bank/broker	5.9	4.8	1.1
Franchising	0.7	0.0	0.7
Construction	5.0	1.0	4.0
Consulting/engineering	2.3	1.1	1.2
Management consulting	1.1	0.9	0.2
Engineering	1.2	0,2	1.0
information/technology	12.1	3.1	9.0
Education	2.2	0.2	2.0
Information	1.6	0.5	1.1
Licensing	5.5	1.0	4.5
Software	2.9	1.4	1.5
Transportation/travel	32.2	39.2	(7.0)
Transportation	18.5	22.8	(4.3)
Travel	13.7	16.4	(2.7)
Other	9.4	3.6	5.8
Health	1.8	0.0	1.8
Motion pictures	1.9	1.5	0.4
Miscellaneous [a]	5.7	2.1	3.6
Total	77.5	65.7	11.8

[a]Affiliated and affiliated fees (excluding royalties and license fees included under "licensing"), expenditures in the U.S. by foreign governments and international organizations, receipts from Canadian affiliate trade unions, miscellaneous commissions, wages of U.S. residents abroad, spending by temporary resident aliens, and other private miscellaneous services.

NOTE: Values given are rounded mid-points ( )= Negative.

SOURCE: U.S. Congress, Office of Technology Assessment, Trade *in Services: Exports and Foreign Revenues-Special* Report, OTA-ITE-316 (Washington, DC: U.S. Government Printing Office, September 1986)

traditions of doing business typically make it more difficult for a foreign firm to provide useful banking services than to sell a manufactured product. For example, U.S. banking laws greatly limit banks with branches in different States and prevent many kinds of direct industrial financing.[38]

There seems to be only one potential threat to the U.S. rank as leader of the financial services industry: Japan. Japanese banks now hold more international deposits than their U.S. counterparts: 26 percent of the total at the beginning of 1986, compared to 24 percent for U.S. banks.

Citicorp used to be the world's largest bank, but of the top 50 current banking concerns in the world, 18 are Japanese, 16 are European, and only 9 are American. In March of 1985, eight of the top ten banks were Japanese, and Citicorp was fifth.[39] Six of the ten largest banks in California were foreign-owned in 1984, up from two in 1979.[40]

The vast accumulation of wealth in traditional U.S. insurance firms gives them potentially great power in overseas markets. The largest five insurers in the world—Prudential, Metropolitan, Aetna, Equitable, and Cigna—and 14 of the largest 25, are American. Of the rest five are Japanese and six are European.[41] However, U.S. insurance companies have been protected at home from competition with other financial institutions, and may therefore not be able to compete effectively for insurance business in foreign markets.

[38]See Stephen Cohen and John Zysman, *Manufacturing Matters: The Myth of a Post-Industrial Economy* (New York, NY: Basic Books, 1987)

39 Worldscope, Wright Investor's Service and Center for International Financial Analysis&Research, 1986, reported in The *Wall Street Journal*, European edition, Oct. 6, 1986.

[40]*San Francisco Chronic/e,* July 20, 1984, p. 37.

[41]Worldscope, op. cit., footnote 39.

Because business services need to be carefully tailored to the needs of individual clients, they typically require close association with the firm being serviced. Advanced telecommunications systems may permit closer working relationships with clients abroad, but it is not yet apparent that these links will be able to substitute for the close personal relationships required for many legal, accounting, and other service functions. As a result, jobs in transactional services like banking and business services tend to be susceptible to the indirect effects of trade in other sectors, particular-y manufacturing (see ch. 7 and table 7-10).

Software[42]

The computing capability of all information systems depends on software, which has the qualities of both a service and a product. While computer hardware manufacturers continue to develop a large amount of software, a rapidly growing software industry has also emerged. The U.S. software industry is the largest in the world, and is also the world's largest exporter. In 1985, U.S. firms controlled about 70 percent of the world software market and earned some $21 billion. Foreign sales totaled $4 billion. The largest portion of these revenues came from the sale of operating systems and applications software for large, mainframe computers. With few exceptions, foreign firms lag well behind U.S. firms in software technology as well as in sales.

Although U.S.-based firms have been market leaders for some time and will continue to be highly competitive, their share of the world market seems destined to shrink somewhat in coming years. Foreign software firms will improve their relative positions, particularly as they follow the U.S. lead in switching to packaged (as opposed to customized) software. While European firms—led by France, which has the second most competitive software industry after the United States—have been quite visible internationally, over the long run Japan is likely to emerge as the major U.S. competitor in software. Japanese government and industry have made major commitments to improve software productivity and to create new generations of software technology.

U.S. leadership in the industry resulted from its domestic market–by far the largest in the world. With the interdependence of hardware and software design growing stronger, this should prove a continuing source of strength for the U.S. industry. Other traditional sources of strength in the U.S. industry are a large number of skilled personnel, strong R&D programs with substantial Federal funding, and strong and flexible U.S. capital markets. U.S. Government policies that ensure access to foreign markets can help maintain existing U.S. advantages in this industry. The future strength of the U.S. industry, however, depends most critically on its ability to master fourth generation languages, on artificial intelligence, and on progress in automating the production of software.

Income From Technology

The United States appears to be doing well in the sale of technology. In 1984, the United States enjoyed a $9 billion trade surplus in sales of information of all kinds: educational services (foreign students overwhelmingly choose technical subjects), royalties, licenses, and information (again see table 9-5). Licensing alone earned $4.5 billion in 1984.

Income from technology transfer has shown steady growth over the past decade. Most U.S. revenues from royalties and fees (76 percent) came from developed countries, with Japan's portion rising from 3 percent in 1967 to 7 percent in 1981.[43] Large U.S. firms appear to prefer transferring technology to subsidiaries through joint ventures, rather than licensing to independent firms. The desire to avoid licensing varies, however, according to the age of the technology, the size of the licenser, and the importance of the market to which the technology is licensed.

U.S. receipts from education were also positive. A growing fraction of the science and engineering students in the United States are foreign. In 1981, 23 percent of all graduate science and engineering students, and 43 percent of all engineering students, were foreign.[44]

[42] This section is drawn largely from *International Competition in Services,* op. cit., footnote 35.

[43] Meryl L. Kroner, "U.S. International Transactions in Royalties and Fees, 1967-78," Survey *of Current Business,* January 1980, p. 25; and U.S. Department of Commerce, unpublished tables; cited in National Science Foundation, Science *Indicators* 2982, Washington, DC, 1982.

[44] *Science* Indicators 1982, op. cit., footnote 43, p. 122.

The positive U.S. performance in technology trade is mirrored in the negative "technology balances" of the Nation's major trading partners. Both West Germany and Japan have been aggressive importers of foreign technology, as have Spain, Italy, and the Netherlands. This pattern is reflected in the positive, though shrinking, balance of patents granted to U.S. firms and individuals, and foreign nationals.

The statistics cited above, however, provide an extremely poor and possibly misleading measure of the value of technology flowing across national borders.[45] Information flows within a firm's divisions or within subsidiaries of multinational firms are notoriously difficult to measure, though it is estimated that 40 percent of all U.S. trade may be intra-firm.[46] Conversely, it is not clear that subsidiaries of foreign firms operating in the United States transfer significant amounts of technology to the United States. There is ample anecdotal evidence to suggest that Japanese automobile firms (such as the Toyota-GM venture) keep the most technologically sophisticated parts of their operations at home, sending only the relatively low-technology assembly operations to the United States.

On the other hand, the Japanese partners in Boeing's 767 aircraft venture participated precisely because they hoped to use the experience to learn things about aircraft production that either were not for sale or could not be sold because they involved complex, hands-on "know how." NEC has learned enough about computers from foreign partnerships to attract a partnership with Honeywell, in which NEC and the Bull company will develop and produce computers and Honeywell will primarily provide marketing services, Komatsu learned an enormous amount about diesel engines from Cummins Engines. In no case does it appear that the U.S. partner learned significantly from its foreign partner.[47]

Perhaps more importantly, there are compelling reasons to believe that the real value of a technology cannot be fairly reflected in its price, since the buyer cannot know its full value in advance. Frequently, a technology purchased for one purpose turns out to have its greatest potential in an entirely unexpected area (the technology for the "compact disk" system, for example, was not purchased with sound reproduction in mind). The social value (or the social cost) of the innovation is very different from the value a firm can place on a technology in the open market.[48]

In addition, enormous amounts of technology are transferred embedded in equipment. Proprietary technologies and associated end-products are frequently introduced abroad through a subsidiary, joint venture, or licensing agreement. These technology transfers account for an important component of the return to U.S. firms on R&D done in the United States and thus constitute an additional incentive to R&D expenditure. One survey has found that 30 percent of the returns from 30 major firms' R&D was expected to come from foreign sales or foreign utilization.[49]

While the trade surplus in information could be taken to demonstrate the continued technological dominance of the United States, it may also show a greater willingness and ability on the part of foreign governments and firms to scan world markets actively for new technology. The potential loss in U.S. competitiveness resulting from this trade surplus in technology sales may well outweigh the immediate income generated from the sales. The reluctance, or inability, of U.S. firms to purchase technology from abroad may be due to various factors, ranging from corporate cultures that have grown up with the assumption that foreign technologies are inferior, to policies on the part of foreign governments that hamper the outflow of technological knowledge. In any event, it is not yet clear whether the

[45] Raymond Vernon, "Technology Transfer Between the U.S. and other Industrialized Countries," paper prepared for the Office of Technology Assessment, Mar. 13, 1984.

[46] John Hein, "What the Trade Numbers Hide," *Across the Board,* vol. XXIV, No, 10, October 1987, pp. 12-13; and James S. Little "Intra-Firm Trade: An Update," New *EngLand Economic Review,* May-June 1987, pp. 46-51.

[47] Yves Doz, Gary Hamel, and C.K. Prahalad, "International Strategic Partnerships–Success or Surrender?" paper delivered to the Strategic Management Society, Singapore, 1986.

[48] A detailed study of 17 industrial innovations found that their social rate of return was more than double the before-tax private rate of return. See E. Mansfield and A. Romeo, "Technology Transfer to Overseas Sub sidiaries of U.S.-based Firms," *Quarter/y Journal o/Economics, vol. 95, 1980,* pp. 737-750. By definition, high-technology industries are R&D intensive. Even so, the concentration of private industrial R&D in these sectors is surprising. The Department of Commerce found, for example, that only 10 R&D-intensive industries accounted for more than 60 percent of total private industrial R&D, although they represented only 13 percent of the value of manufacturing product shipments; see "An Assessment of U.S. Competitiveness in High Technology Industries," op. cit., footnote 3.

[49] Ibid.

trade surplus in "information" services should be considered an asset or a liability.

It is widely agreed that the production of knowledge is an area in which the difficulty of securing property rights induces market failure, with the result that there may be inadequate research in areas where property rights cannot be exercised and excessive research in areas where they can.[50] Given the already rapid diffusion of the technologies discussed above, the counterfeiting of trademarked commercial merchandise and the theft and duplication of intellectual property have become major international issues. There have been extensive efforts to achieve multilateral agreements in this area,[51] but so far progress has been disappointing. Political pressure is building for bilateral action. The United States has already pressured Hong Kong, Taiwan, Singapore, and South Korea to clamp down on offenders on the grounds that without adequate protection, new investors might be reluctant to establish themselves abroad and to transfer technology.

Existing agreements involving intellectual property rights administered under the World Intellectual Property Organization (WIPO) are less than adequate. They build on principles of national treatment, but statutes vary significantly from country to country and enforcement is usually weak or non-existent. Provisions for the settlement of international disputes are lacking. Additional problems are created by the nature of technological change itself.

50 For more on this subject, see U.S. Congress, Office of Technology Assessment, *Intellectual Property Rights in an Age of Electronics and Information, OTA-CIT-302* (Washington, DC: U.S. Government Printing Office, April 1986).

51 In 1979, the United States and the European Economic Community (EEC) reached agreement (ad referendum) on the text of a code to deter international trade in counterfeited trademarked merchandise. Over the next 2 years, the United States and the EEC intensified efforts to broaden participation in the code, resulting in multilateral discussions with a number of GATT countries, including Canada and Japan. These talks resulted in a revised text to be used as the basis for negotiation of a code acceptable to all GATT members. While the agreement was accepted by the four major countries, the counterfeit code was shelved at the 1982 GATT ministerial meeting. Some less developed countries opposed any mention of the issue in the GATT, arguing that it fell under purview of the World intellectual Property Organization (WIPO) rather than the GATT. Though the Ministerial meeting directed the Director-General of the GATT to hold consultations with WIPO, little progress has been recorded to date.