

GLOBALIZING INDUSTRIAL RESEARCH AND DEVELOPMENT

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FOREWORD

The research and development (R&D) enterprise is truly becoming a global entity. Foreign and U.S. companies are investing in R&D facilities around the world at a record pace. They are seeking to reap the rewards of foreign scientific and technical discoveries, take advantage of human resources, and tailor their R&D to host country customer needs.

Since 1987, the Office of Technology Policy's Asia-Pacific Technology Program has helped U.S. companies and researchers leverage foreign science and technology through the publication of high-quality technical assessments and studies, and its many other activities. This study, *Globalizing Industrial Research and Development*, continues our tradition of providing U.S. organizations with the specialized information they need to make educated business decisions on technology-related questions.

A wide range of practical questions and policy concerns arise from the rapid growth of the global R&D enterprise. How many foreign R&D facilities are there in the United States? In what industries and regions is this investment most concentrated? Are we seeing an erosion of U.S. science and technology leadership? What is the real importance of the globalization of R&D? What motivates firms to invest in R&D facilities overseas? Are there short-term or long-term benefits for the U.S. economy?

Globalizing Industrial Research and Development makes a significant contribution to the process of answering these questions by shedding new light on the magnitude, scope, and nature of foreign R&D investment in the United States. It expands and updates Office of Technology Policy's earlier seminal study published in 1992. Much has changed since we completed that study. Our 1992 study listed just 250 U.S. research facilities of foreign companies. That number has grown to 645 facilities owned by more than 300 parent companies. We also include for the first time a comparative section on U.S. R&D investment abroad and provide a partial listing of U.S. overseas R&D facilities. Finally, our discussion highlights the most current data from the National Science Foundation (NSF) and the Commerce Department's Bureau of Economic Analysis (BEA) on these important matters.

The views expressed are those of the authors and editors and not necessarily those of the Department of Commerce.

Graham R. Mitchell
Assistant Secretary of Commerce for Technology Policy

EXECUTIVE SUMMARY

R&D spending in the United States by foreign-owned companies is now more than \$14.6 billion, making it large enough to have an influence on the overall growth rate of total private R&D in the United States. This report sheds important light on the magnitude, the nature, and the scope of this investment. It also explores the major factors influencing the location decisions of foreign R&D facilities in the United States. This information is important in increasing our understanding of the dynamics of R&D as well as the flow of high-value-added jobs.

In a complementary trend to increased foreign R&D investment in the United States, U.S. companies have substantially increased their R&D spending abroad, nearly doubling it between 1987 and 1993. This report details this trend and the rationale for U.S. research activities abroad. The overall globalization of the R&D enterprise is clearly illustrated by the actions of both U.S. and foreign firms.

This report also finds that the investment motivations for U.S. R&D abroad and for foreign R&D in the United States are strikingly similar. These motivations range from assisting the parent company to meet host country customer needs and monitor technological developments, to allowing the firms to take advantage of specialized skills in the host country. U.S. and foreign companies primarily conduct applied research abroad. The pharmaceutical and biotechnology industries also carry out large-scale basic research in offshore locations.

Foreign R&D Investments in the United States: Key Findings

- R&D expenditures by foreign-owned companies in the United States more than doubled, from \$6.5 billion in 1987 to \$14.6 billion in 1993, and accounted for more than 15 percent of total U.S.-company funded R&D. R&D spending by foreign-owned companies in the United States increased at a much faster pace than R&D spending by U.S. firms within the United States.
- Foreign companies accelerated the establishment or acquisition of R&D facilities in the United States. At the end of 1994, foreign companies owned more than 645 facilities designated as R&D centers in the United States. These facilities are owned by more than 300 foreign parent companies.

R&D expenditures by foreign-owned companies in the United States more than doubled, from \$6.5 billion in 1987 to \$14.6 billion in 1993.

More than half of U.S. R&D expenditures abroad are accounted for by U.S. affiliates in five countries: Germany, United Kingdom, Canada, France, and Japan.

- The 224 Japanese R&D facilities in the United States outnumber the U.S. R&D facilities of other countries. The United Kingdom has the second-largest number of facilities (109), followed by Germany (95) and France (52). The number of U.S. R&D facilities owned by Korean parent companies has more than doubled, from about a dozen in 1992 to 27 in 1995.
- At the end of 1993, foreign-owned companies conducting R&D in the United States employed more than 105,000 R&D workers.
- Switzerland ranks first in R&D expenditures by foreign companies in the United States, spending \$2.5 billion in 1993. It is followed by Germany (\$2.3 billion), the United Kingdom (\$2.2 billion), Canada (\$2.2 billion), and Japan (\$1.7 billion).
- The largest impact on R&D spending by foreign companies in the United States resulted from several major acquisitions by foreign firms of U.S. pharmaceutical and biotechnology companies with large R&D budgets.
- Industries with the largest number of foreign facilities are drugs and biotechnology (113), chemicals and rubber (109), automotive (53), computer software (44), computers (39), and semiconductors (35). Japanese firms have the largest number of R&D facilities in the automotive and electronics industries.
- Foreign R&D facilities in the United States are heavily concentrated in some areas of the country, such as Silicon Valley and greater Los Angeles (CA), Detroit (MI), Princeton (NJ), Research Triangle Park (NC), and Boston (MA).
- The most frequently cited reasons for investing include (1) to assist parent companies in meeting U.S. customer needs; (2) to keep abreast of technological developments in the United States; (3) to employ U.S. scientists and engineers; and (4) to cooperate with other U.S. R&D laboratories.

U.S. R&D Investments Abroad: Key Findings

- U.S. companies have increased their R&D spending abroad from \$5.2 billion in 1987 to \$9.8 billion in 1993. More than half of U.S. R&D expenditures abroad are accounted for by U.S. affiliates in

five countries: Germany, United Kingdom, Canada, France, and Japan.

- In recent years, R&D spending by U.S. affiliates in newly industrializing or developing countries has increased. These countries include Singapore, Brazil, Mexico, and Hong Kong.
- Several major studies show that, while the amount of U.S. R&D abroad has increased, leading-edge R&D on a company's core technology is still performed at home. About 90 percent of R&D expenditures by U.S. companies still is spent at their facilities in the United States.
- In 1993, most of the expenditures on U.S. R&D abroad were concentrated in the following sectors: drugs, chemicals, automotive, computers, and services.
- Of the 108 U.S. facilities listed, Europe contains 62 facilities, followed by Japan with 29 and Canada with 14.

1. TRENDS IN U.S. R&D EXPENDITURES BY FOREIGN-OWNED COMPANIES

During the past six years, research and development (R&D) expenditures by foreign-owned businesses in the United States (U.S. affiliates of foreign firms in which a foreign parent company owns at least 10 percent of the affiliate's equity) have increased at a much faster pace than total R&D expenditures within the United States by U.S. firms. R&D spending in the United States by foreign-owned companies is now large enough to have an influence on the overall growth rate of total private R&D in the United States. In the high-technology sector, R&D expenditures by foreign companies account for one out of every five dollars spent on corporate R&D in the United States. The growth in R&D spending by foreign companies in the United States can largely be attributed to the expansion of R&D expenditures by the U.S. affiliates of multinational companies from six countries: Switzerland, Japan, United Kingdom, Germany, France, and Canada.

In the high-technology sector, R&D expenditures by foreign companies account for one out of every five dollars spent on corporate R&D in the United States.

Total R&D spending within the United States by U.S. firms rose about 57 percent, from \$61 billion in 1987 to \$96 billion in 1993. In comparison, R&D expenditures by U.S. affiliates of foreign companies increased by 146 percent during the same period.

Company-Funded R&D Expenditures

Data on R&D spending by U.S. and foreign-owned companies are collected through surveys of companies by the U.S. Commerce Department's Bureau of Economic Analysis (BEA)¹ and the National Science Foundation (NSF)². BEA data are based on annual surveys of the R&D expenditures of U.S. affiliates of foreign companies in the United States. The NSF publishes two series of industry R&D statistics: (1) Total funds (company, federal, and other) and (2) company and other (except federal) funds. The term "company-funded" R&D refers to the NSF industry R&D series excluding federal funds and covers R&D performed within the United States by both U.S.-owned and foreign companies.

Both the BEA and NSF surveys use similar Standard Industrial Classification (three-digit) industry classifications for their company or enterprise-based surveys, although some companies perform R&D in various industries. Because the BEA and NSF surveys limit their definition of R&D expenditures by foreign-owned companies to funds spent at company-operated R&D facilities, the data from both surveys are conservative estimates of R&D expenditures. Both surveys exclude other types of foreign-sponsored R&D, such as foreign company-sponsored research at U.S. universities. However, the NSF conducts (at two-year intervals) a separate survey of contract research in the United States.

Rising Share of Foreign Funding of U.S. R&D

According to BEA survey data, R&D spending by U.S. affiliates of foreign companies more than doubled from \$6.5 billion in 1987 to \$14.6 billion in 1993. With the exception of the years 1991 and 1993, R&D expenditures by U.S. affiliates of foreign companies have increased at a rate of 15 percent or more per year since 1987. The significant expansion of foreign R&D expenditures in the United States could partially be attributed to several major acquisitions by foreign multinationals of U.S. firms. Although there was a widespread surge in the late 1980s in acquisitions in many industries, such as computers, semiconductors, steel, and tires, the largest

¹ U.S. Department of Commerce, Bureau of Economic Analysis, *Foreign Direct Investment in the United States: Operation of U.S. Affiliates of Foreign Companies* (Washington, DC: Government Printing Office, annual).

² National Science Foundation, Division of Science Resources Studies, *Selected Data on U.S. Research and Development in Industry* (Washington, DC: National Science Foundation, annual).

impact on R&D funding was in the acquisition by U.S. pharmaceutical and biotechnology firms with large R&D budgets. Ciba Geigy's purchase of a 49.9 percent stake in Chiron and Hoffman LaRoche's investment in Genentech are examples.

As previously mentioned, R&D expenditures by foreign companies in the United States have grown much faster than total R&D expenditures by U.S.-owned firms within the United States. Total R&D spending within the United States by U.S. firms rose about 57 percent, from \$61 billion in 1987 to \$96 billion in 1993. In comparison, R&D expenditures by U.S. affiliates of foreign companies increased by 146 percent during the same period. As shown in Figure 1, the foreign share of total company spending in R&D reached a plateau of about 9 percent from 1981 to 1985, but then quickly increased in the second half of the 1980s.

A major upward revision of the NSF data for the period since 1989 makes it difficult to compare trends in the foreign share of U.S. R&D in the 1990s with earlier periods. As a result of a new sample design, the NSF data now better reflect R&D performance among firms in the service sector and small firms in all industries and resulted in increased estimates of industrial R&D in the United States by 15 to 20 percent in the 1990s. The dip in the foreign share of U.S. R&D in 1991 shown in Figure 1 is primarily due to the revised upward shift in the NSF data used in the denominator; R&D by foreign-affiliated companies continued to expand in 1991, although at a slower rate, 3 percent. (See Figure 2.) The percentage of foreign-funded R&D out of total company-funded R&D with the revised NSF data was 14.5 percent in 1992, compared with 17.3 percent using the previous NSF series in the denominator.

Country Shares

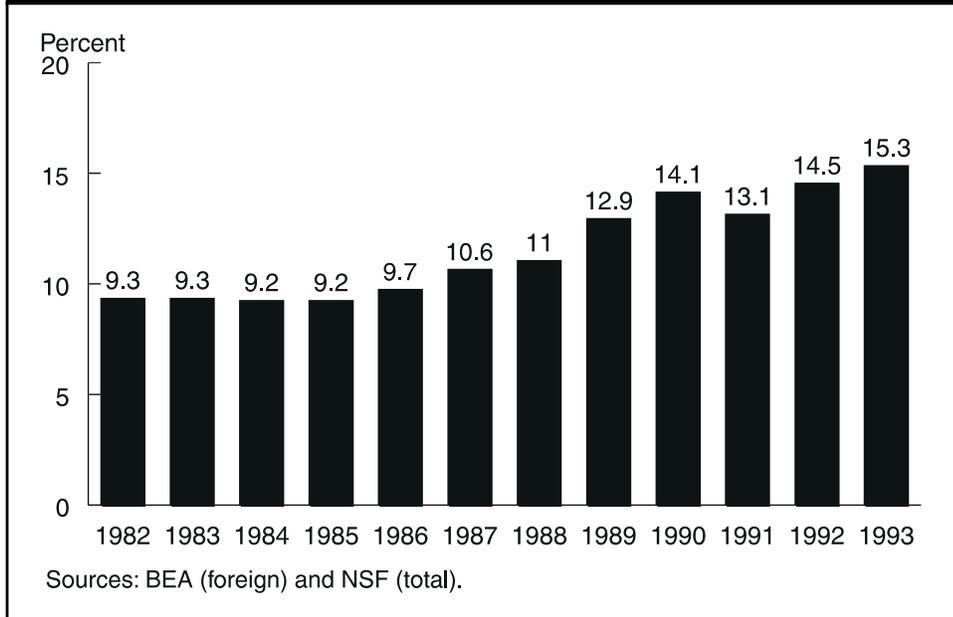
R&D spending within the United States by foreign-owned businesses increased \$8.1 billion between 1987 and 1993. Most of the growth has come from an increase in R&D spending by U.S. affiliates of multinational companies from four countries: Japan, United Kingdom, Switzerland, and Germany (Table 1). Japanese-funded R&D in the United States, which increased from \$307 million in 1987 to \$1.8 billion in 1993, experienced the most rapid rate of growth.

Japan ranked fifth in total U.S. R&D spending by affiliates in 1993, behind Switzerland (\$2.52 billion), Germany (\$2.32 billion), United Kingdom (\$2.30 billion), and Canada (\$2.19 billion). Japan's share of the U.S. total

Japanese-funded R&D in the United States, which increased from \$307 million in 1987 to \$1.8 billion in 1993, experienced the most rapid rate of growth.

In 1993, U.S. R&D spending by foreign-owned companies was concentrated in three industries: drugs, electronics, and industrial chemicals, which accounted for more than 60 percent of R&D expenditures by foreign-owned companies in the United States.

Figure 1. Foreign-Affiliated Companies' Share of U.S. R&D (company-funded R&D)

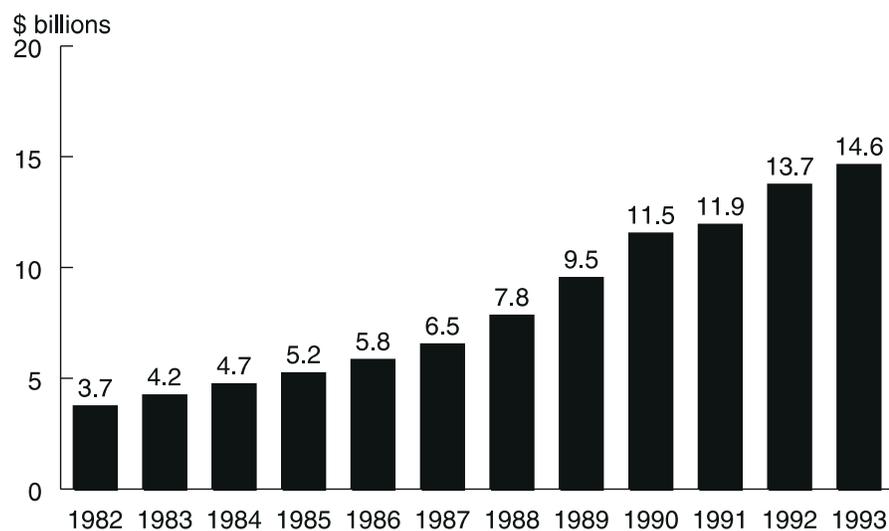


R&D expenditures by foreign-owned companies in the United States (12.2 percent) trailed the shares of Switzerland (17.2 percent), Germany (16 percent), United Kingdom (15.7 percent), and Canada (15 percent) but was significantly larger than the shares of France (8.2 percent) and the Netherlands (4.7 percent).

Industry Distribution

Foreign-affiliated companies are concentrating their U.S. research activities on a few industry sectors, reflecting to a large degree the industry concentration of their direct investments in the United States. The industry composition for affiliates of foreign-owned companies from the BEA survey data is shown in Figure 3. In 1993, U.S. R&D spending by foreign-owned companies was concentrated in three industries: drugs, electronics, and industrial chemicals, which accounted for more than 60 percent of R&D expenditures by foreign-owned companies in the United States. These companies spent far less of their U.S. R&D funds on machinery (excluding computers) and transportation equipment than U.S. companies. About 12 percent of R&D funds were allocated to nonmanufacturing—services and wholesale trade.

Figure 2. R&D Expenditures by Affiliates



Source: BEA.

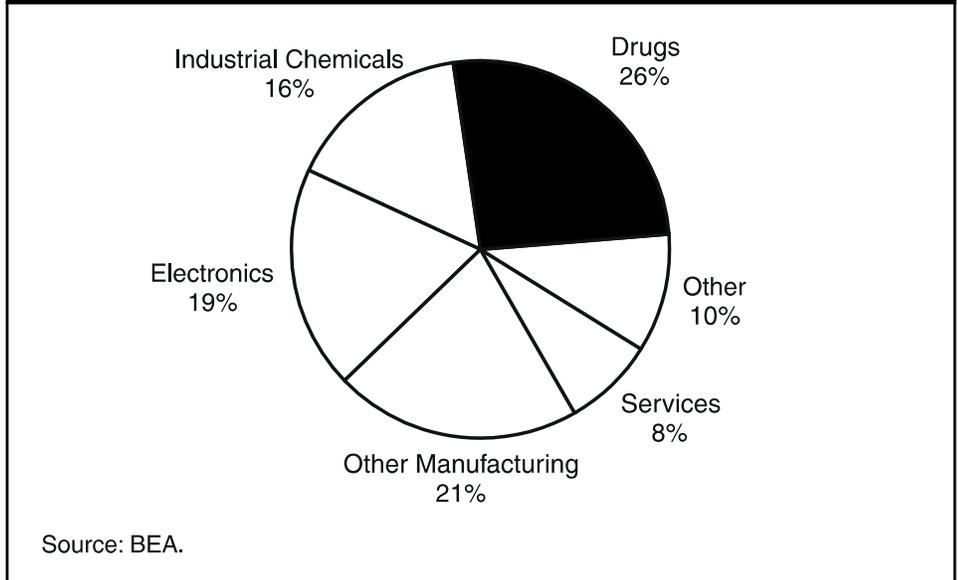
Table 1. R&D Expenditures and Employment by Affiliates of Foreign Companies

Country	Expenditures		R&D Employees (thousands)
	1987 (\$ millions)	1993	
All countries	6,521	14,618	105.2
Switzerland	765	2,524	14.7
Germany	1,139	2,321	19.2
United Kingdom	833	2,295	20.0
Japan	307	1,781	11.8
France	366	1,204	9.3
Netherlands	542	691	6.3
Canada*	1,666	2,190	10.3

*Canadian affiliates include a major U.S. chemical company with a minority Canadian investment.

Source: BEA, *Foreign Direct Investment in the United States*.

Figure 3. Industry Distribution of R&D Expenditures by Foreign-Affiliated Companies in the U.S., 1993



Another measure of the concentration of the R&D expenditures of U.S. affiliates of foreign companies in high-technology industries is the amount of spending relative to the NSF survey data for R&D by all companies (see Table 2). U.S. affiliates accounted for 45 percent of total private R&D funding in industrial chemicals and plastics and synthetics, 38 percent of all funding in drugs and medicines (including biotechnology), and 33 percent of audio, video, and communications equipment.

High concentrations of foreign funding in R&D in these industries generally reflect the concentration of foreign ownership of businesses in these industries, as measured by sales or employment. Establishment data on foreign-owned shares of U.S. industries from a joint survey program by BEA and the Bureau of the Census for 1991 show that foreign-owned establishments accounted for nearly 30 percent of shipments for industrial inorganic chemicals, 40.5 percent of plastic materials, 37.4 percent of drugs, 11.7 percent of computer equipment, 25.3 percent of communications equipment, 71.5 percent of household audio and video, 13 percent of electronic components, and 12.8 percent of instrumentation.³

³ BEA and Bureau of the Census, *Foreign Direct Investment in the United States: Establishment Data for Manufacturing, 1991* (Washington, DC: U.S. Government Printing Office, April 1994).

Table 2. Percentage of R&D Expenditures by U.S. Affiliates to R&D by All Companies for Selected High-Technology Industries, 1993

Industry	U.S. Affiliates (\$ millions)	All Companies (\$ millions)	Percent of Total R&D
Industrial chemicals	2,329	5,152	45.2
Drugs and medicines	3,370	8,822	38.2
Computers and office equip.	765	10,650	7.2
Audio, video, comm. equip.	1,135	3,435	33.0
Electronic components	282	3,428	8.2
Scientific and prof. instruments	588	7,426	7.9

Sources: BEA (U.S. affiliates) and NSF (all companies).

2. FOREIGN R&D FACILITIES IN THE UNITED STATES

The basis of the material in this section is the list in Appendixes A and B of 645 foreign-owned R&D facilities in the United States. Appendixes A and B list the foreign R&D facilities in the United States by industry and by source country, respectively. The Office of Business and Industrial Analysis of the Economics and Statistics Administration, U.S. Department of Commerce, compiled the list from several sources. Most of the information on foreign R&D facilities in this list was provided by companies through directory surveys and public announcements, although the authors did not attempt to verify the accuracy of every listing and generally relied on company classification and definition of an R&D facility. Earlier versions of the list in Appendixes A and B have been published previously, but this report includes the latest expanded data.⁴

⁴ See Donald H. Dalton and Manuel G. Serapio, Jr., *U.S. Research Facilities of Foreign Companies* (U.S. Department of Commerce, NTIS, Office of Japan Technology, PB93-134328, January 1993).

The R&D facility typically operates under its own budget, is overseen by its own group of officers, and is located in a freestanding facility outside of and separate from the other U.S. facilities (e.g., sales and manufacturing facilities) of the parent company.

Table 3. Foreign R&D Facilities in the United States, 1994

Country	Companies	Facilities
All countries	306	645
Japan	107	225
United Kingdom	61	109
Germany	32	95
France	22	52
Switzerland	16	47
Netherlands	11	26
Korea	10	27
Sweden	14	22
Canada	5	8
Italy	6	8
Finland	5	5
Denmark	3	4
Belgium	1	2
Norway	2	2
Australia	2	2
Israel	2	2
Taiwan	2	2
Austria	1	1
Ireland	1	1
Spain	1	1
Hong Kong	1	1
Singapore	1	1
Venezuela	1	1
Netherlands Antilles	1	1

Source: Appendix B.

Definition of a Foreign R&D Facility in the United States

For purposes of this report, we define a foreign R&D facility in the United States (also referred to as an R&D center, R&D company, or R&D laboratory) as a freestanding R&D company site (i.e., a facility engaged mainly in R&D) of which 50 percent or more is owned by a foreign parent company. The R&D facility typically operates under its own budget, is overseen by its own group of officers, and is located in a freestanding facility

outside of and separate from the other U.S. facilities (e.g., sales and manufacturing facilities) of the parent company.

Our definition of an R&D facility excludes R&D departments or sections within the U.S. affiliates (e.g., marketing offices and manufacturing plants) of foreign-owned companies. (R&D expenditures performed by U.S. affiliates of foreign-owned businesses are discussed in Chapter 1 of this report.) For example, Toyota Motor Corporation conducts R&D at Toyota Technical Center in Torrance, CA. Toyota's manufacturing affiliate, New United Motor Manufacturing Inc. (NUMMI), also conducts R&D on a limited basis in its plant in Fremont, CA. We define the former (i.e., Toyota Technical Center in Torrance) as a foreign R&D facility and the latter (R&D done at NUMMI) as R&D expenditures performed by a U.S. affiliate of a foreign company.

Our definition also excludes R&D performed by third-party organizations, such as R&D conducted by U.S. research universities, or third-party contractors that are financed by a foreign company. In addition, our definition only includes those foreign R&D facilities in the United States of which 50 percent or more are owned by the foreign parent company. Because we rely on company classifications of R&D facilities, the range of activities may vary across industries and nationalities, and includes activities that are not strictly R&D (i.e., product customization, design centers, and technology scanning).

R&D Facilities, by Country and by Industry

Table 3 and Appendix A list 645 R&D facilities that are wholly or partially owned by 309 foreign companies. As shown by Table 3, the 225 Japanese R&D facilities in the United States far outnumber the U.S. R&D facilities of other countries, accounting for nearly 35 percent of the 645 total foreign-owned facilities. United Kingdom is second with 109 facilities, followed by Germany (95), France (52), and Switzerland (47). South Korea has a growing R&D presence in the United States, with 27 R&D facilities.

The large number of U.S. R&D laboratories of Japanese companies is partially a result of the relatively large number of Japanese parent companies with R&D facilities in the United States—107 companies in 1994, compared with 61 British parent companies, 32 German parent companies, and 22 French parent companies.

Japanese R&D facilities in the United States far outnumber the U.S. R&D facilities of other countries, accounting for nearly 35 percent of the 645 total foreign-owned facilities.

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Table 4. U.S. R&D Facilities of Foreign Companies, 1994

Industry	Japan	Germany	Korea	Nether-lands	United Kingdom	Switzer-land	Sweden	France	Others
Computers	22	4	7	3					3
Computer software	27	4	1	1	6			3	1
Semiconductors	19	3	10	2					
Telecommunications	15	4	1		2	1	2	2	3
Optoelectronics	11	3			2		1		3
High-definition TV, other electronics	33	9	4	4	10	5		4	3
Drugs, bio-technology	25	18	1	5	23	17	6	11	9
Chemicals, rubber, materials	24	28		4	19	10		17	8
Metals	5	1			3	1	1	4	2
Automotive	34	11	3		1		2	2	
Machinery	7	2			4		6	3	5
Instrumentation, controls	1	3		3	23	6	1	6	
Foods, consumer goods, misc.	7	6		7	19	6	1	2	7

Source: Appendix A. Columns include double counting of facilities that perform R&D in more than one industry.

In terms of industry distribution, the industries with the largest number of foreign-owned R&D centers in the United States are drugs and biotechnology (116 facilities), chemicals and rubber (110 facilities), automotive (53 facilities), computer software (43 facilities), and computers (39 facilities). Japanese companies account for most of the R&D centers in the electronics and automotive industries, while European companies have far more drugs and chemicals R&D laboratories. (See Table 4.)

Size: Largest R&D Facilities

Table 5 lists the largest foreign research centers in the United States in terms of staff size. The largest foreign laboratories are concentrated in pharmaceuticals, automotive, and electronics. Of the 35 foreign R&D facilities in Table 5, 24 are owned by European companies. The majority of these European R&D facilities are in pharmaceuticals and biotechnology.

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Table 5. Largest Foreign Research Centers in the United States

Company	Location	Prof. Staff
1. Pharmacia (SWE)	Upjohn Laboratories, Kalamazoo, MI	1,318
2. Northern Telecom (CAN)	Research Triangle Park, NC	1,260
3. SmithKline Beecham (UK)	King of Prussia, PA	1,198
4. Siemens (GER)	Iselin, NJ	1,100
5. Glaxo (UK)	Research Triangle Park, NC	1,000
6. Burroughs Wellcome (UK)	Research Triangle Park, NC	891
7. Honda (JA)	Marysville, OH (2); Torrance, CA; Denver, CO	800
8. Hoechst (GER)	Somerville, NJ	716
9. Hoffman-LaRoche (Swiss)	Genentech, San Francisco, CA	672
10. Sony (JA)	San Jose, CA	600
11. Bayer (GER)	Miles, West Haven, CT	500
12. Glaxo (UK)	Sterling Drug, Rensselaer, NY	450
13. Hoechst (GER)	Marion Merrell Dow, Kansas City, MO	411
14. Nestle (Swiss)	Westreco, New Milford, CT	410
15. Nestle (Swiss)	Alcon Labs, Fort Worth, TX	404
16. Rhone-Poulenc (FR)	Fort Washington, PA	400
17. Bayer (GER)	Miles, Pittsburgh, PA	389
18. Hoffman-LaRoche (Swiss)	Nutley, NJ	350
19. Toyota (JA)	California (4), Ann Arbor, MI	350
20. Rhone-Poulenc (FR)	Research Triangle Park, NC	350
21. Unilever (NE/UK)	Edgewater, NJ	329
22. Nissan (JA)	Farmington, Ann Arbor, MI; Los Angeles, CA	320
23. Northern Telecom (CAN)	San Ramon, CA	319
24. Northern Telecom (CAN)	Rochester, NY	280
25. PA Consulting (UK)	Hightstown, NJ	250
26. Zeneca (UK)	Wilmington, DE	245
27. Moore (CAN)	Grand Island, NY	235
28. Thomson (FR)	Indianapolis, IN	230
29. Mazda (JA)	Flat Rock, Ann Arbor, MI; Irvine, CA	213
30. Racal (UK)	Sunrise, FL	209
31. Goldstar (KO)	United Micro Tech, NJ	200
32. Siemens (GER)	Gammasonics, Hoffman Estates, IL	200
33. Siemens (GER)	Rolm, Boca Raton, FL	200
34. OSRAM (GER)	Sylvania, Danver, MA	200
35. Dainippon Ink & Chemical (JA)	Reichold Chemicals, Research Triangle Park, NC	186

Source: Compiled by the authors from *Directory of American Research and Technology* (New Providence, NJ: R.R. Bowker, Inc., 1994).

Japanese companies initially established R&D laboratories in California and recently have begun moving east, while European companies began on the East Coast and are moving west.

Japanese companies account for about 20 percent of the companies listed in Table 5, mostly in the automotive industry.

Although staff size is not available for all of the 645 R&D facilities listed in Appendixes A and B, the available data indicate that the pharmaceutical, biotechnology, and automotive R&D laboratories are much larger than the electronics R&D facilities. In the electronics industry, the available data also indicate that Japanese R&D centers in the United States are much smaller than their European counterparts. This finding could be explained by the fact that several of the Japanese laboratories are much newer and have not yet reached full staffing. In addition, the disparity in staff size between the European and Japanese companies could be attributed to a difference in research focus. Japanese electronics companies tend to focus their R&D on a single technology at each site in the United States,⁵ while European firms tend to establish large central laboratories covering many technologies. However, it is important to note that some Japanese companies (e.g., Sony) are consolidating their electronics R&D operations in fewer locations in California.

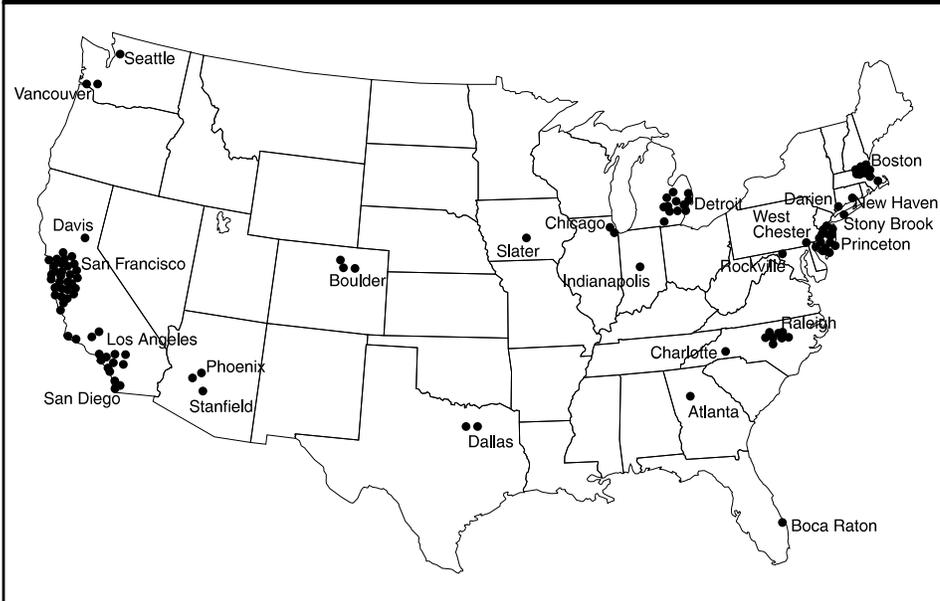
Location

Foreign R&D facilities in the United States are highly concentrated in some areas of the country, as shown in Figure 4. Japanese companies initially established R&D laboratories in California and recently have begun moving east, while European companies began on the East Coast and are moving west. The largest concentration of R&D facilities is in California's Silicon Valley, which attracted large numbers of laboratories in computers, semiconductors, and computer software. The Los Angeles metropolitan area has a smaller number of R&D facilities with a more diverse group of companies, including auto design and styling centers.

Another major cluster of R&D centers is in New Jersey, especially around Princeton University. Many of the major European drug and chemical companies have located near U.S. drug company research centers in New Jersey, and to a lesser degree in Pennsylvania and Connecticut. Research Triangle Park in North Carolina ranks third and is a center for biotechnology research for both U.S. and foreign companies. The Boston area ranks fourth, especially for its proximity to computer companies and access to Massachusetts Institute of Technology (MIT) faculty.

⁵ For a discussion of single-technology facilities by Japanese companies, see Eleanor Westney, "Cross-Pacific Internationalization of R&D by U.S. and Japanese Firms," *R&D Management*, Vol. 23 (2), 1993.

Figure 4. Foreign Research Centers in the United States



The major source countries have their facilities in states with large concentrations of R&D facilities by U.S. companies and proximity to research universities.

Some areas are highly specialized in certain industries, such as Detroit for automotive laboratories and Richardson, TX, for telecommunications research facilities. Specialized expertise in certain university departments has attracted biotechnology laboratories to the Seattle (University of Washington) area, while the Boulder-Denver-Longmont area (University of Colorado) has attracted computer disk drive labs.

Table 6 lists the states with most R&D facilities of foreign companies with major R&D investments in the United States. Although the facilities are located across 30 to 40 states, the major source countries have their facilities in states with large concentrations of R&D facilities by U.S. companies and proximity to research universities.

Nature and Scope of Operations

Automotive Industry—Of the 53 automotive R&D facilities listed in Appendix A, 34 are Japanese companies, 16 are European companies, and three are South Korean companies. The U.S. R&D facilities of automotive companies—Japanese automotive companies in particular—conducted little R&D when they first started operations in the United States. Instead, their main activities were testing emissions for certification requirements

Since the late 1980s, foreign automotive companies, especially Toyota, Nissan, Mazda, and Honda, have expanded the scope of their R&D activities in the United States.

Table 6. States with the Most Foreign R&D Facilities, 1995

State	No. of Facilities
California	146
New Jersey	75
North Carolina	32
Ohio	22
Massachusetts	21
Pennsylvania	21
Michigan	20

Note: R&D facilities of major source countries: Germany, United Kingdom, Japan, Canada, Switzerland, France, Netherlands, Korea.
Source: Compiled from Appendix B.

and scanning the regulatory environment. They also evaluated the performance of their own and competitors' vehicles and monitored U.S. automotive design and styling trends.

Since the late 1980s, foreign automotive companies, especially Toyota, Nissan, Mazda, and Honda, have expanded the scope of their R&D activities in the United States. Several facilities have undertaken projects in advanced concept design (i.e., the design of future vehicles), joint research, and vehicle prototype production. Also, these facilities have become more involved in parts and materials design and evaluation of local suppliers. An example of such higher valued-added activities is the lead involvement by Toyota's Caltex Research Design Center, in California, in the exterior design of the Lexus/Soarer Coupe. Mazda's design center in California also assisted in developing the Miata sports car, and Honda's U.S. research facilities in Ohio played a major role in developing a new Accord model for the U.S. market.

Drugs and Biotechnology—The pharmaceutical and biotechnology industries account for the largest number of foreign R&D facilities in the United States, with 113 facilities in 1994. These industries also have the largest (in terms of staff size) foreign-owned R&D facilities in the United States and are the primary area for basic research by foreign companies. Most of the facilities are owned by European companies, with high concentrations of German, Swiss, and British drug companies. In addition, many of the European drug companies, such as BASF and Hoechst, have large operations in the chemicals markets.

Foreign investment in U.S. R&D in drugs and biotechnology has been characterized by acquisitions of U.S. firms. A new wave of mergers is occurring in the industry. In 1995, several major mergers and acquisitions were announced: Hoechst's decision to acquire Marion Merrell Dow; the merger of two large British companies, Glaxo and Burroughs Wellcome; and the merger of Upjohn with a Swedish company, Pharmacia. In 1994, Ciba Geigy, a Swiss company, increased its stake in Chiron, a U.S. biotech company, to 49.9 percent, and Roche Holding, another Swiss company, acquired Syntex. Major acquisitions of U.S. companies in earlier years include Roche's purchase of a majority stake in Genentech and the acquisition of Rorer by Rhone-Poulenc, a French company. In 1987, the British firm, Beecham, acquired SmithKline Beckman.

In the biotechnology industry, foreign R&D facilities fall into two basic groups: laboratories that conduct research in recombinant DNA and monoclonal antibody technologies, and R&D centers involved in pharmaceuticals, chemicals, and agribusiness. The former are small laboratories with capitalization of \$50 million or less; the former are among the largest foreign R&D facilities in the United States.⁶

Electronics—Foreign-owned facilities in the electronics area reflect a diversity of corporate interests and strategies across many industries, from the giant European telecommunications equipment and electronics company facilities to many small single-technology labs operated by Japanese companies. Japanese R&D facilities far outnumber the R&D facilities of other countries in computers, semiconductors, and computer software. Most of the foreign-owned R&D facilities in electronics conduct applied research with some activities in developing new applications of existing technologies or products or tailoring products to customer needs. A small group of facilities conducts basic research. These facilities include the NEC Research Institute (Princeton, NJ), Philips, Siemens, Canon, and Panasonic Technologies (Matsushita).

Investment Motives—Foreign companies have invested in R&D facilities in the United States for different reasons. Table 7 lists 10 reasons cited by senior R&D/technical executives of foreign R&D facilities in the automotive, biotechnology, and electronics industries. Of these, two reasons were cited as important by most R&D facilities: to acquire technology and to keep abreast of technological developments in the United States. As could be expected, firms that deal with technologies in which U.S. firms conduct leading research (e.g., biotechnology, software design, certain new

The pharmaceutical and biotechnology industries account for the largest number of foreign R&D facilities in the United States.

⁶ For more details, see Manuel G. Serapio, Jr., and Donald H. Dalton, "Foreign R&D in the United States," *IEEE Spectrum*, November 1994.

OFFICE OF TECHNOLOGY POLICY

**Table 7. Reasons for Foreign R&D Investments in the United States
Given by Senior R&D/Technical Executives
(1 = extremely important, 2 = important, 3 = neutral, 4 = unimportant)**

	Electronics	Autos	Biotechnology
Acquire technology	1	2	1
Keep abreast of technological developments	2	2	1
Assist parent company in meeting U.S. customer needs	1	1	3
Employ U.S. scientists and engineers	2	3	2
Follow competition	3	3	4
Take advantage of favorable research environment	4	4	1
Cooperate with other U.S. R&D labs	2	3	2
Assist parent company in meeting U.S. environmental regulations	4	1	4
Assist parent company's U.S. manufacturing plants in procurement	4	2	4
Engage in basic research	3	4	2

Source: Interview survey of Japanese companies by Manuel G. Serapio, Jr., published in Manuel G. Serapio, Jr., and Donald H. Dalton, "Foreign R&D Facilities in the United States," *Research Technology Management*, Industrial Research Institute, November–December 1993.

Two reasons were cited as important by most R&D facilities: to acquire technology and to keep abreast of technological developments in the United States.

materials) cite these two reasons as important. Firms that deal with technologies in which foreign companies lead or are equal to U.S. firms (e.g., consumer electronics) cite the reasons mentioned above as unimportant.

The growth of foreign R&D investments in the U.S. automotive industry is directly linked to the expansion of Japanese and European automotive manufacturing facilities in the United States. Two reasons cited as important by automotive firms were (1) "assisting the parent company in meeting U.S. environmental regulations" and (2) "assisting the parent company in meeting U.S. customer needs." Other important reasons were "assisting the parent company's U.S. manufacturing plants in local procurement" and "keeping abreast of technological developments in the United States."

In the biotechnology industry, “taking advantage of a more favorable environment for research,” “cooperating with other U.S. R&D laboratories,” and “engaging in basic research” were cited as important factors influencing the decision of foreign firms to invest in U.S. R&D facilities. Other studies have also noted that “access to U.S. research universities,” “availability of scientists for employment by foreign-owned employers,” and “spillovers from U.S. private research” are prime inducements for the growth in foreign-owned R&D centers in biotechnology and drugs. In particular, Japanese drug companies appear to be mainly motivated to gain access to U.S. biotechnology discoveries, partly because of relative weakness in their domestic biotechnology research capabilities. Japanese drug companies have established a U.S. presence for other reasons, including conducting their own clinical testing for new drugs for the U.S. market and acquiring U.S. technology to bolster competitiveness in the Japanese market.⁷

The most important aspect of the favorable research environment in the United States is a U.S. policy encouraging research in biotechnology and related fields. Robert Fujimura of the U.S. Food and Drug Administration, a leading expert in biotechnology, attributes the excellent environment for research in his field to leading-edge research in life sciences now being conducted in the United States. He believes that this has been due in part to substantial and sustained support by the U.S. government and the participation of top scientists and researchers from all over the world. In contrast, European firms, and German companies in particular, maintain that the biotechnology research environment has been largely unfavorable in Europe.

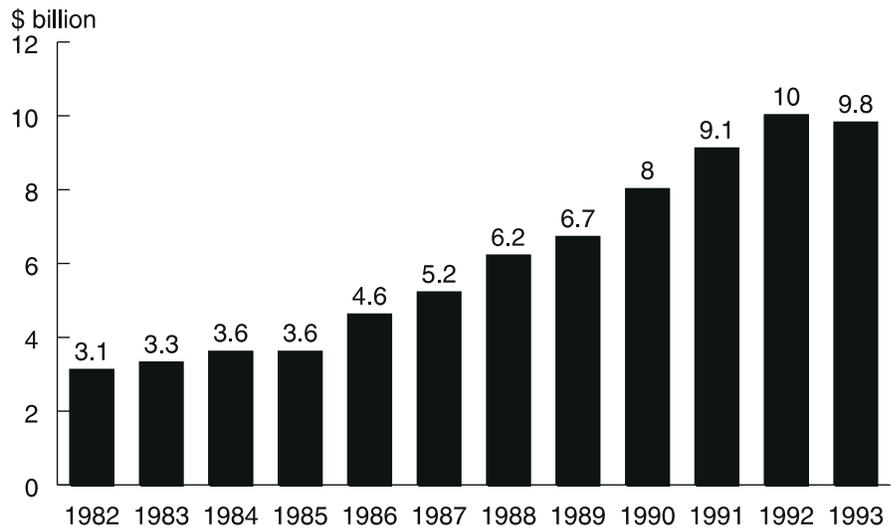
In the electronics industry, “assisting the parent company in meeting U.S. customer needs” was cited as an important motive for investing in R&D facilities in the United States. Foreign firms have used their U.S. R&D facilities to monitor technological developments in the United States, customize products to the specifications of U.S. customers, and facilitate concurrent design and development. Another important factor influencing the decision is the growing complexity and speed of innovation in new technologies. A senior executive of a Japanese company told the authors that “Acquiring technology has become a more complex task. Without an actual presence in the United States, it is difficult for us to judge what technology is worth buying from U.S. companies. We built

The most important aspect of the favorable research environment in the United States is a U.S. policy encouraging research in biotechnology and related fields.

⁷ Tom Roehl, *The Role of International R&D in the Competence-Building Strategies of Japanese Pharmaceutical Firms*, College of Commerce and Business Administration, University of Illinois at Urbana-Champaign, CIBER Working Paper No. 94-008, 1994.

Foreign firms have used their U.S. R&D facilities to monitor technological developments in the United States, customize products to the specifications of U.S. customers, and facilitate concurrent design and development.

Figure 5. U.S. R&D Abroad



Source: NSF.

our R&D centers in the United States to establish a base that will help us make these decisions.” An executive from a software company expressed a similar opinion that the rapidity of technological change in the computer software industry dictated the company’s presence in the United States in order to “keep up with day-to-day developments” in the U.S. software industry.

3. U.S. R&D FACILITIES ABROAD: A COMPARISON

Are European, Japanese, and other foreign companies the only organizations expanding their overseas R&D operations? As shown by Figure 5, U.S. companies are also increasing their R&D activities abroad. According to the NSF survey, R&D expenditures by U.S. multinational companies have nearly doubled since 1987, increasing from \$5.2 billion in 1987 to \$9.8 billion in 1993. R&D expenditures by American companies abroad accounted for an additional 11 percent of all private U.S. expenditures on R&D in 1993, up from 6.4 percent in 1985 and 8.5 percent in 1987.⁸ Com-

⁸ Both the NSF and BEA publish annual data on U.S. R&D abroad based on company surveys. The NSF data series provides data only for industry classifications; the BEA series publishes separate data for industries and countries. U.S. R&D abroad is not included in the NSF series on company-funded R&D because it is not performed within the United States.

pared with overseas sales, which are more than 30 percent of total sales of U.S. multinational companies, most of the R&D expenditures by these companies are spent at their U.S. facilities. The slight decline in U.S. R&D abroad in 1993 may indicate a slowdown in the rate of growth, reflecting the recent problems in U.S. industrial R&D funding.

In 1993, most of the expenditures on U.S. R&D abroad were concentrated in drugs, chemicals, automotive, computers, and services. The largest R&D expenditures by U.S. multinationals in 1993 were in Germany (\$2.6 billion), United Kingdom (\$1.6 billion), Canada (\$1.0 billion), and France and Japan (\$0.9 billion each). U.S. R&D investments in newly industrializing countries have increased significantly, with Singapore ranked 10th in U.S. R&D expenditures abroad, followed by Brazil, ranked 12th (see Table 8).

Direct investments by U.S. multinational companies are nothing new. U.S. multinational firms such as IBM, Caterpillar, and Union Carbide, have operated R&D facilities abroad for many years. In a pioneering study of R&D abroad by U.S. multinational companies, Robert Ronstadt noted that IBM spent about \$200 million (roughly 30 percent of its budget) in 1974 in overseas R&D. Other companies, such as Otis Elevator, CPC International, and Exxon, spent 50 percent, 38 percent, and 25 percent of their R&D budgets, respectively, in overseas R&D in the 1970s.⁹

R&D Facilities

An NSF study identified 70 U.S. R&D facilities in Japan, including joint ventures, which employed more than 5,000 people.¹⁰ Of these facilities, more than half were established or acquired during the past seven years. Some of the newly established U.S. R&D facilities in Japan include Apple Computers and Texas Instruments. General Motors recently expanded its technical center, GM Asian Technical Center, in Japan. Likewise, Ford Motor Company has announced plans to expand its R&D presence in Japan. Other companies with a long-standing presence in Japan include IBM, DEC, and Caterpillar.

⁹ Robert C. Ronstadt, *Research and Development Abroad by U.S. Multinationals* (New York, NY: Praeger, 1977).

¹⁰ National Science Foundation, *Survey of Direct U.S. Private Capital Investment in Research and Development Facilities in Japan*, NSF 91-312, 1991.

R&D expenditures by U.S. multinational companies have nearly doubled since 1987, increasing from \$5.2 billion in 1987 to \$9.8 billion in 1993.

Of [U.S. R&D facilities in Japan], more than half were established or acquired during the past seven years.

Table 8. Expenditures for U.S. R&D Abroad, by Country

Country	1989 (\$ millions)	1993
1. Germany	1,496	2,568
2. United Kingdom	1,673	1,639
3. Canada	914	1,030
4. France	545	942
5. Japan	488	862
6. Ireland	134	669
7. Belgium	317	460
8. Netherlands	360	392
9. Spain	115	321
10. Singapore	25	312
11. Italy	294	304
12. Brazil	90	220
13. Australia	181	176
14. Switzerland	67	109
15. Mexico	37	76*
16. Hong Kong	n/a	74
17. Sweden	33	48
Total	7,048	10,954

* 1992 R&D data.

Source: BEA, *U.S. Direct Investment Abroad*, annual.

Appendix C provides a partial list of U.S. R&D facilities abroad. Of the more than 108 U.S. R&D facilities listed in Appendix C, 62 are in Europe, 29 in Japan, 14 in Canada, 2 in Brazil, and 1 in Singapore. These facilities cover a wide range of industries, including computer hardware, software, consumer electronics, automotive, pharmaceuticals, consumer products, and chemicals.

Comparison of Investment Motivations

A recent study published by the Japan Technology Program of the U.S. Department of Commerce compared the motivations and activities of U.S. electronics R&D facilities in Japan and Japanese facilities in the United States. The single most important investment motives cited in the inter-

view study of both U.S. R&D in Japan and Japanese R&D in the U.S. were as follows:

1. Assist the parent company in meeting the host country company needs.
2. Monitor technological developments.
3. Acquire/generate new technology.

The most important location decision for U.S. R&D in Japan and Japanese R&D in the United States was “availability of scientists and engineers,” and the majority of facilities focused primarily on applied research and development.¹¹

4. R&D GLOBALIZATION ISSUES

Rapid growth of foreign R&D in the United States has led to concerns about an erosion of U.S. science and technology leadership, a potential decline in U.S. industrial competitiveness, and the clustering of foreign R&D centers around major U.S. research universities that receive large shares of their funding from federal grants and other taxpayer support. Some observers have questioned the quality of the research effort by foreign companies; others have raised doubts about the importance of the globalization of R&D.

Direct Benefits

One area of consensus concerns the short-term benefits. Direct benefits to the United States include funding for R&D within the United States and employment opportunities for U.S. scientists and engineers. In 1993 foreign companies spent \$14.6 billion in the United States on R&D and employed 105,200 R&D workers. Without the foreign spending in recent years, U.S. company-funded R&D performed in the United States would have been stagnant or declined. Foreign funding of academic research and equipment purchases has been welcomed by university researchers in a period of declining federal funding.

Direct benefits to the United States include funding for R&D within the United States and employment opportunities for U.S. scientists and engineers.

¹¹ Manuel G. Serapio, *Japan-U.S. Direct R&D Investments in the Electronics Industries*.

Foreign-funded R&D has similar local spillovers and indirect benefits compared with U.S. R&D.¹² Local communities benefit from the presence of highly paid scientists and engineers and spinoffs of research into new companies. Other U.S. companies in the same industry may benefit from the new products and processes developed from basic research by foreign companies. A study by Coe and Helpman suggests that international R&D may lead to an increase in economic growth.¹³

R&D Intensity

Some observers have argued that the U.S. research centers of foreign companies are merely “listening posts” that focus on technology scanning with only a small research effort. Although this description may have applied to the early stages of U.S. research by affiliates, foreign firms have committed substantial resources, \$14.6 billion in 1993, to their U.S. research facilities. The expenditure on R&D of U.S. affiliates of foreign companies was 2.6 percent of sales in 1992, compared with 3 percent for all U.S. companies. However, the R&D to sales ratio varies across industries, and the percentage was much larger in the pharmaceutical industry, 11.7 percent for affiliates, than for U.S. drug companies, 9.7 percent.¹⁴ In our study, we found that Japan’s automotive R&D has moved from an early stage of design work and emissions testing to more value-added research in developing new vehicles for the U.S. market. A major effort in basic research is conducted by affiliates in the chemicals, drugs, and biotechnology industries.

Extent of Globalization

Another issue in the debate about the quality of U.S. R&D by foreign companies is based on studies that raise questions as to whether globalization of R&D is an important source of new technology. A recent

¹² For a detailed analysis of local R&D spillovers see Adam B. Jaffe, Manuel Trajtenberg, and Rebecca Henderson, “Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations,” *Quarterly Journal of Economics*, August 1993.

¹³ David T. Coe and Elhanan Helpman, *International R&D Spillovers*, National Bureau of Economic Research, Working Paper, No. 4444, August 1993.

¹⁴ For more detailed data on the R&D intensity of U.S. affiliates of foreign companies and a comparison with U.S. R&D intensity, see William J. Zeile, “Foreign Direct Investment in the United States: 1992 Benchmark Survey Results,” *Survey of Current Business* (Washington, DC: July 1994).

report by the Office of Technology Assessment concluded from an interview study of U.S. R&D managers that leading-edge R&D on a company's "core" technology is performed only at a company's central labs in the home country.¹⁵ Some empirical research by Patel and Pavitt on the location of patents by large multinational companies shows that most of their patents are filed in the home country.¹⁶ The results from patent data are supported by the expenditure data on U.S. firms' R&D abroad, which show that about 90 percent of R&D expenditures by U.S. companies are spent at their facilities in the United States. Cantwell found similar results for British companies on the concentration of R&D in the home country.¹⁷

Technology Transfer

New research has begun to look at some indirect benefits from the cross-fertilization of research between parent labs and their U.S. subsidiaries. Methe has found that long-term benefits from overseas research require organizational learning in the parent firm, characterized by a "double loop" of two-way flows of technology that becomes well integrated into the parent firm.¹⁸ Too often, cross-border research involves "content knowledge" in reporting information on new discoveries, rather than "process knowledge," which involves learning about the process of U.S. basic research that can be used by the parent firm. The interaction between the R&D of the parent and that of its U.S. affiliate may have long-term benefits for the U.S. R&D community because 90 to 95 percent of the affiliates' R&D employees are U.S. scientists and engineers who can transfer this experience to other U.S. R&D companies.

¹⁵ For a discussion of a survey of U.S. firms about their "core" technology, see U.S. Congress, Office of Technology Assessment, *Multinationals and the U.S. Technology Base*, Washington, DC: September 1994.

¹⁶ Pari Patel and Keith Pavitt, "Large Firms in the Production of the World's Technology: An Important Case of Non-Globalization," *Journal of International Business Studies* First Quarter, 1991.

¹⁷ J.A. Cantwell and C. Hodson, "Global R&D and British Competitiveness," in M.C. Casson (ed.) *Global Research Strategy and International Competitiveness*, Oxford: Basil Blackwell, 1991.

¹⁸ David Methe and Joan Penner-Hahn, Joan, *Globalization of Japanese Pharmaceutical Research and Development: Implications for Organizational Learning* (School of Business Administration, University of Michigan, Presentation at the Association of Japanese Business Studies annual meeting, Ann Arbor, June 1995).

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In summary, foreign R&D in the United States has some clear benefits in taking up the slack from the cutbacks by large U.S. R&D firms and the reduction in federal funding. The foreign share of U.S. company-funded R&D has grown with the foreign ownership share in the U.S. economy. Foreign-owned companies account for about 15 percent of U.S. manufacturing output,¹⁹ and their share of U.S. company-funded R&D is in the same range. The global economy enables U.S. companies to benefit from foreign technical advances, and technical alliances with foreign-funded R&D centers in the United States and global networks can add to the technical base of the United States.

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¹⁹ BEA and Bureau of the Census, *Foreign Direct Investment in the United States: Establishment Data for Manufacturing*, 1991.

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