Chapter 6

Technology Trade: Licensing by U.S.-Based Firms

CONTENTS

Boxes

Figures

Tables

Chapter 6

Technology Trade: Licensing by U.S.-Based Firms

SUMMARY

Corporations trade in technology in world markets just as they do in other services and goods—that is, they trade in the knowledge used to produce other goods and services. Mostly this is proprietary technology—knowledge that a firm can control, much of it protected under U.S. law if not always under the legal systems of other countries. Traded technology includes management methods and techniques, as well as knowledge embodied in equipment, in manuals and specifications, patents, in computer software. It also includes disembodied knowledge—know-how that exists only in people's heads or in organizational routines. Today, licensing agreements may be part of complex business arrangements that include equity participation by the licenser, training for the licensee's employees, and contracts to supply parts or components and buy back finished goods. Licensing is becoming an integral part of the international business strategies of American corporations, rather than a means of generating incremental profits from a company's store of technical knowledge.

Compared with other items in the U.S. balance of payments, international licensing is not a big business. Foreign technology sales by American firms, measured by royalties and licensing fees, amounted to $5.8 billion in 1985 (table 23), By value, transactions between U. S.-based parent companies and their overseas affiliates exceed those between unaffiliated firms. Receipts from affiliates account for about 70 percent of U.S. licensing revenues, although making up only 10 to 20 percent of the number of agreements.[1]

[1] F, J, Contractor, *Licensing in International Strategy.. A Guide for Planning and Negotiations* (Westport, CT: Quorum Books, 1985), p. 27, in 1977—the latest year for which such data are available—American corporations had 23,600 overseas 1 ice n ses in force, 3,500 of them (15 percent) with affiliated foreign firms (those owned 10 percent or more by an American company – see table 23, footnote b).

Much of the analysis in this chapter is based on interviews conducted hy (3TA staff and contractors.

Table 23.—U.S. International Receipts, Payments, and Net Receipts of Royalties and Licensing Fees (billions of dollars)[a]

	Receipts	Payments	Net receipts
Licensing between affiliated firms:[b]			
1978	$2.7	$0.4	$2.3
1980	3.7	0.3	3.4
1982	3.5	0.3	3.2
1984	3.9	0.6	3.3
1985	4.1	0.5	3.7
Licensing between unaffiliated firms:			
1978	$1.2	$0.3	$0.9
1980	1.3	0.3	1.0
1982	1.7	0.3	1.4
1984	1.6	0.4	1.3
1985	1.7	0.4	1.3
Total, affiliated plus unaffiliated:			
1978	$3.9	$0.7	$3.2
1980	5.0	0.6	4.4
1982	5.2	0.6	4.6
1984	5.5	1.0	4.6
1985	5.8	0.8	5.0

[a] While far from perfect, the data collected by the Bureau of Economic Analysis (BEA part of the Department of Commerce)–summarized in table 23 and used elsewhere in the chapter—are the best available Throughout this chapter OTA utilizes BEA's data on 'royalties and licensing fees' as a measure of technical licensing The broader BEA category ' royalties and fees though more commonly used Includes management fees and a variety of other charges that may have little to do with technology trade The royalties and license fees series as presented in this table shows significantly different trends than for instance the International technical licensing series published by the National Science Foundation in their biennial *Science Indicators* OTA s choice conforms with BEA's practice, beginning in 1986, of separating 'royalties and license fees and "other private services from affiliated foreigners in the balance of payments statistics.

For BEA's collection procedures, together with the possible sources of error and ambiguity, see *Trade in Services Exports and Foreign Revenues* (Washington, DC Office of Technology Assessment, September 1986) pp 29.30, pp 8385 summarize the impact of licensing on the U S balance of payments

Net receipt figures may not add because of rounding

[b] U S affiliates, as defined by the Department of Commerce include all foreign firms with 10 percent or more of equity owned by a U S parent The data make no distinction between minority (1 O to 50 percent} and majority ownership although this distinction has Important practical implications for control over the affiliate, and thus for licensing arrangements

BEA presents affiliated licensing data only on a net basis That is the affiliated receipts in the table equal payments by subsidiaries abroad to their U S parents minus payments by these parents to their subsidiaries U S affiliated payments equal payments by U S affiliates to their foreign parents minus their receipts from those foreign parents In 1982, payments by U S parents to their subsidiaries came to less than 2 percent of the receipts of these parents For affiliated payments, the difference is more substantial In 1980 payments flowing from foreign parents to their U S subsidiaries came to about 12 percent of the payments of U.S subsidiaries to their parent firms

The affiliated payments series were revised for 1980 and again for 1982 and later, and may not be directly comparable with earner years

SOURCES Receipts and unaffiliated payments, 1978 and 1980 Department of Commerce, Bureau of Economic Analysis, unpublished statistics, January 1986 table 6— U S International Transactions in Royalties and Fees with telephone corrections **Affiliated payments, 1980** *Foreign Direct Investment in the United States, 1980* (Washington DC Department of Commerce 1983), table L-1 p 198 1982-85 R C Krueger 'U S International Transactions, First Quarter 1986,' *Survey of Current Business* June 1986 p 43

Particularly for transactions between majority-owned affiliates, the dollar values in table 23 do not necessarily mean much; intra-corporate charges may have more to do with, say, minimizing worldwide tax liabilities than with the market value of the licensed technology. At the same time, license fees represent only a small fraction of the foreign sales generated through applications of the transferred technology, Assuming royalty rates at 5 percent of sales, not untypical, U.S. technology licensing would lead to some $116 billion in foreign product sales, a figure more than half of total U.S. merchandise exports ($214 billion in 1985), Viewed as an alternative means of exploiting proprietary technology, then, licensing has great significance for American businesses. Many licensing agreements also lead to exports of capital goods, components, or materials.

As table 23 indicates, American companies also purchase technology developed overseas, but in small amounts compared with their exports. This picture is changing, more slowly than it probably should. Today, few U.S. firms enjoy technical positions so strong that they could not benefit from selective acquisitions of foreign know-how. U.S. advantages in technology have not only narrowed, they have, in more than a few fields, vanished. Some American companies realize how much they can learn from foreign technical developments; others do not. For a growing number of U.S. firms, acquisition of foreign technology has become an important element of corporate strategy, as a substitute for or complement to internal research and product development. The steel industry provides many recent examples, with Nippon Steel, for one, providing technical assistance to USX (formerly U.S. Steel), Armco, and Inland. Technology exchanges with Japan have also been common in microelectronics and robotics.

What does international competitiveness mean in terms of licensing? On one level, licensing can be viewed as an international business in its own right; in a very real sense, American firms compete with rivals abroad in selling technical information. Their ability to compete depends on the U.S. technology base, on relative rates of technological development in this country and abroad, and on the entire array of factors influencing the Nation's store of technical knowledge.

At the same time, licensing—as a vehicle for transferring technical information—can cause changes in the competitive positions of the industries that buy and sell technology. American firms licensed a great deal of microelectronics technology to Japanese manufacturers during the 1960s and 1970s, reducing the time required for Japan to become internationally competitive. The obvious question follows: Have American firms licensed their technology too cheaply? Put differently, while 1icensors presumably look out for their own interests, is there any reason to expect them to account for impacts, possibly adverse, on other companies in their own industry or in other American industries? The costs and benefits for the three fundamental alternatives—licensing, exports, direct investment—may differ considerably from the perspective of the firm with technology to exploit and from the perspective of the U.S. economy as a whole. More than one executive has been moved to accuse his counterparts in other U.S. companies of giving away the Nation's technological advantages through too liberal licensing,

At the same time, in a world of sprawling multinational corporations (MNCs), questions of national technological position quickly become fuzzy, Most international licensing (by value) is carried out between the divisions of such companies (table 23); licensing has become an integral part of global competitive strategy for multinationals, If a U, S.-based MNC has investments in several dozen countries and garners half or more of its sales overseas, does its store of proprietary technology count as U.S. know-how? Some of it does, but probably not all. At the most fundamental level, it is people who embody and convey technical knowledge, R&D carried out by the MNC's employees in the United States counts in the U.S. technology base; R&D conducted overseas may be transferred back to the United States, or may not be. The real point is that the MNC has a good deal of control over its technology, nations with open economies have relatively little; the U.S.

Government can support R&D, adding to the Nation's technology base, but, as a government, has only limited means for retaining that technology within U.S. borders. It may be more important (and more practical) to pursue policies aimed at drawing in foreign technologies than to pursue policies aimed at slowing the outflow of U.S. technology.

Arms-length licensing transactions with both industrialized and newly industrializing nations raise questions of technological comparative advantage most starkly, The issues concern the sources of technical knowledge, the ability to preserve and take advantage of proprietary technology, including the learning and other dynamic effects so important in competitive outcomes, and the Federal Government's role in supporting R&D and technology development. They range from needs for better research equipment in the Nation's universities, to international regimes for protecting intellectual property, to foreign government policies aimed at inducing American companies to license or otherwise transfer their technology, In many countries, trade barriers make it difficult or impossible for American firms to export directly. Governments may also restrict investment by American firms, cutting off the option of local production. Since the 1960s, foreign governments have become far more sophisticated in bargaining with multinationals; integrated corporate strategies have been, in part, a response to foreign government efforts to extract technology.

For a variety of reasons, explored in this chapter, the technological leads once enjoyed by U.S. firms have diminished substantially. This relative decline carries implications both for international licensing, and, from a competitiveness point of view, for sales of knowledge-intensive products and services. The evidence also points to a decline in R&D productivity in the United States–i.e., that a given expenditure for R&D yields less in terms of commercial innovations than in the past. The implication: both industry and government need to seek ways of improving efficiency —e.g., through better mechanisms for transferring technologies from laboratory to marketplace. Furthermore, given that improving productivity in R&D has never been easy, steady increases in U.S. R&D funding seem necessary. Although the focus in this chapter remains on technology development in the private sector, Federal agencies fund nearly half of all U.S. R&D; government policy initiatives offer many opportunities for improving the Nation's technological competitiveness.

That foreign companies have made relative gains in their capacity to generate commercial technologies should come as no surprise. Most have been and continue to be substantial purchasers of technology from the United States. While some critics take this as meaning that American firms remain their own worst enemies, the evidence suggests otherwise. Before the Second World War, European industries held the lead in many technologies (ranging from chemicals to automatic lathes to prestressed concrete). Japan had a well-developed industrial base by the beginning of the 1930s. After the war, American firms were much better placed to compete, but as Europe and Japan rebuilt, their companies quickly narrowed the gap. In newer fields, those that have opened since the 1960s, the Japanese have been able to enter on a par with American firms, and to keep up or even move ahead. Examples include optical communications and structural ceramics.

Today, companies in Europe and Japan operate with state-of-the-art technologies. Japanese firms now license out more technology than they license in, although Japan continues to be a net importer of technology in terms of ongoing agreements. Indeed, the United States may now have as much to gain as to lose through freer exchanges of technical information. Improving the climate for such exchanges, so that American firms can learn more easily from foreign know-how, will require a shift in U.S. attitudes, along with policy changes in other industrialized nations.

The following points, then, emerge most strongly from the analysis in this chapter:

- In an increasingly integrated world economy, U.S. companies license both at arms-length and to their affiliates. The affiliates themselves license—their own technology, as well as know-how they get from the parent. Technology flows around the world through many channels. Almost any technology will be available to almost any firm with the money and skills to make use of it.

- With licensing a part of business strategies in which joint ventures and other intercorporate alliances have become common, it makes less and less sense to speak of U.S. technology as compared with foreign technology. Corporations control technology when they can; certainly they maintain storehouses of proprietary knowledge. But, granting some exceptions, nations do not.
- Given that many foreign corporations, particularly those in Japan, now have technologies in some respects as good or better than those of American companies, the U.S. economy could benefit from greater inward flows of technical know-how. Access to the world's stock of technology is quickly becoming an issue comparable in significance to the ongoing task of supporting R&D and technology diffusion within the United States. Some U.S.-based firms do seek out and license technologies from overseas, but a broad shift in attitude toward foreign know-how on the part of American corporations seems called for.
- Into the 1970s, many U.S. firms underestimated the capabilities of their potential rivals in Japan, and therefore settled for royalties that experience shows to have been too low. While most of these mistakes are in the past, it remains true that firms look out for their own interests; they do not, in general, look out for the interests of other American companies or for broader U.S. economic interests. The greatest need, at this point, is to develop more effective mechanisms for bringing Japanese technology into the United States.
- Finally, the U.S. technology base as a whole plainly needs attention. Policymakers have acknowledged many of the problems for years: obsolete and inadequate university research facilities; too few American-born graduate students in engineering (and an infrastructure for technology development that increasingly depends on foreign nationals); inadequate mechanisms for transferring technical knowledge from those who have it to those who need it. Despite much talk, little has been done. More serious strains also seem to be emerging: recognition that military R&D spending yields far fewer spillovers on the civilian side of the economy than once expected; evidence of slowdown in R&D productivity; realization that corporate and national priorities here put less weight on developing and using technical knowledge than in other countries.

INTERNATIONAL TECHNICAL LICENSING

Why License?

A company can profit internationally from its technology by licensing to firms abroad, as well as through exports that utilize the technology, or through foreign direct investment (FDI). Seldom would managers put licensing at the top of the list for exploiting their technology in foreign markets. If the company's know-how gives it a competitive advantage, they will want to retain control—much easier within the firm than outside it. Licensing agreements are notoriously difficult to police, and unauthorized actions by licensees not uncommen. Thus managers tend to be quite careful about which technologies they will license, and the conditions for external use. Even when a company builds a plant overseas, it will often choose a legal contract to help safeguard proprietary knowledge, rather than transferring technology informally, particularly with partially owned affiliates.

Beyond these considerations, markets for technology do not work as well as product markets. Buyers and sellers have trouble finding each other. Proprietary technologies may be available from only one firm, with a scattering of near and not-so-near substitutes; with few buyers and sellers for a given technology, pricing becomes uncertain. Neither party—but particularly the potential buyer—can have a very clear idea of a technology's worth. Considerable adaptation and re-engineering may be needed before technologies developed in one company can be used in another; these costs—which may be high and uncertain—reduce the potential returns. For such reasons, the determining factors in setting royalty levels and the rest of the compensation package may be rules of thumb, negotiating skills, and relative bargaining power more than the value of the technology as it would be established in a better developed market. It should be no surprise that less developed countries (LDCs) often complain that they must pay "too much" for technologies, or that some U.S. firms will not license at all outside their own organization. Box U summarizes some of the characteristics of typical licensing agreements.

Despite the difficulties of negotiating mutually satisfactory agreements, licensing revenues continue to increase, as table 23 showed. Why? For three primary reasons:

- First and most important, American companies license abroad when this is the only alternative for exploiting their technical advantages. Trade or investment barriers may restrict foreign investment to minority positions, or foreclose exporting and FDI entirely. (Licensing in Eastern Europe has turned out to be a lucrative business for some American companies.) For smaller firms lacking export experience or an international division, licensing may be the only practical route.
- Second, firms may have other options but nevertheless choose licensing for strategic reasons. Licensing can be a good way to test the waters in an unfamiliar market, or earn revenues in smaller countries or those where political risks are high. Moreover, MNCs have come to view licensing as a valuable tool in crafting complex international strategies. For example, American firms have licensed manufacturers in South Korea and Taiwan to help create stronger competition in the Far East for Japanese firms, as discussed later in the chapter.
- Licensing within the corporation, finally, takes place for a variety of reasons—all of which come down to efforts by the firm to manage international operations rationally. For instance, licenses help with accounting and management control: the division that develops the technology gets the credit. Most important, licensing agreements provide useful mechanisms for transferring funds internationally—mechanisms that may be available even when governments block other flows of funds, or enforce unrealistic foreign exchange controls.

U.S. Receipts and Payments

Foreign investments by American companies have been heavy during the postwar period, with many firms transferring technology to support their overseas manufacturing operations. In 1985, payments from affiliated foreign companies accounted for 70 percent of U.S. licensing receipts ($4, 1 billion of the $5.8 billion total, table 23); payments by U.S. companies totaled only $847 million. But as the table indicates, the Nation's surplus on royalties and licensing fees grew only slightly during the 1980s.

Figure 38 shows that licensing with other industrialized countries accounts for the great majority of U.S. revenues; only 5 percent of affiliated receipts come from LDCs, and 17 percent for unaffiliated receipts. Payments by Japanese and European firms accounted for three-quarters of receipts from affiliates and over half from unaffiliated companies.

While capturing the general patterns, table 23 and figure 38 do not convey a full picture of U.S. licensing. First of all, BEA's data cover all licensing fees, for both new and ongoing agreements. With the average length of agreements in the vicinity of 10 years, trends are slow to emerge; neither the number of new agreements in a given year, nor their value, can be isolated. Second, BEA does not collect data on the value of licensing agreements for which no royalties are charged. In industries like electronics, where cross-licensing is common, com-

Box U.—The License Agreement

When technology is transferred, either domestically or internationally, a formal contract will normally set out the obligations of buyer and seller. The license agreement conveying technology to the buyer sets the conditions on its use—e.g., requiring the recipient to maintain quality standards, limiting the geographical markets in which the technology can be used, prohibiting resale. Compensation can take a variety of forms: a one-time fee; royalties set at a percentage of the licensee's sales; a reciprocal technology transfer; even an equity shareholding in the firm receiving the technology. With the agreements becoming more thoroughly integrated into the ongoing businesses of MNCs, many contracts today incorporate combinations of these payment forms.

Most license agreements cover fixed terms, commonly in the range of 5 to 20 years. Royalty rates vary a good deal, and may be less than 1 percent of sales in the petroleum industry but 15 percent or higher in pharmaceuticals. Given the poorly developed markets for technology, industry norms have a good deal of influence over royalties. Typical rates range downward from 10 to 15 percent in the pharmaceutical industry, to 3 to 5 percent in computers, 2 to 3 percent in chemicals (other than petroleum), and around 2 percent for many consumer products sectors. The rates also vary with other contract provisions; automakers may get royalties of no more than a quarter of a percent, but earn substantial profits from sales of parts and subassemblies to firms that assemble their vehicles under license.[1]

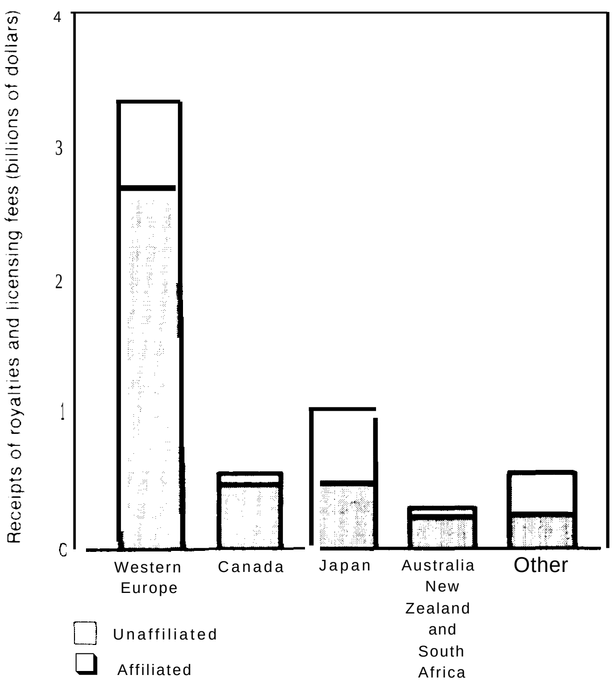
In the simplest case, the agreement gives the licensee the rights to a patent, conveying no other technical information. Because patents are public knowledge, the license amounts to an agreement that the licenser will not sue for infringement. (While copyright and trade secret law, as well as patents, provide protection for intellectual property in the United States, these protections maybe much weaker in other countries—one reason so much licensing takes place between companies that share ownership ties.) The great majority of agreements, however, are designed to transfer technology in a broader sense: the licensing package may convey knowledge in the form of technical manuals, engineering data, manufacturing specifications, administrative procedures and management techniques, trade secrets, and—particularly if the licensee is inexperienced or the technology complex—technical training and assistance. Transferring technology can be a difficult and costly business; often, disembodied or tacit knowledge can only be passed along through experience-based learning, with the licensor's employees working alongside those from the licensee.

Licensing agreements demand management attention past the point of negotiation and transfer of technology. Each party has an interest in the continuing technical capabilities, markets, and strategic plans of the other. One former executive of a large American multinational recalled in an OTA interview a meeting with a group of Japanese representatives to discuss a new licensing agreement between the two firms. The Japanese came prepared with a report summarizing the 300 existing agreements between the two companies, leading the Americans to conclude that their counterparts knew far more about the relationship between the two companies, and were in fact managing that relationship in ways the Americans had not begun to think about.

---

1 Most contractual royalty rates probably fall in the range of 1 to 8 percent of sales-*Licensing in International Strategy: A Guide for Planning and Negotiations* (WestPort, CT: Quorum Books. 1985), pp. 9, 75,222. See pp. 106-109 for survey results on the content of licensing agreements> showing, for example, that the great majority of licensing agreements make explicit provision for technical assistance to the licensee.

Figure 38.— Geographic Distribution of U.S. Technical Licensing Receipts, 1985



SOURCE R C Krueger U S International Transactions First Quarter 1986 *Survey of Current Business* June 1986 pp 65-66

panics may trade a great deal of quite valuable technology with no money changing hands. Finally, there is little information on technology transferred by the overseas affiliates of American firms, which themselves license to perhaps another 10,000 foreign firms.[2]

As noted, growth in the U.S. surplus on licensing slowed during the 1980s, primarily because receipts increased by only $800 million from 1980 to 1985 (table 23). Payments by U.S. firms for foreign technology, although still much smaller than receipts, have been rising. Unfortunately, it is hard to tell how fast inward licensing has been increasing, because of the cumulative nature of the statistics; these, as pointed out above, lump new agreements together with payments for licenses negotiated 10 or 20 years ago.

Many other indicators do provide evidence that foreign firms have been catching up technologically. For example, U.S.-based MNCs now transfer technologies to their affiliates much earlier in the product cycle than in the earlier postwar period. q Such trends, together with past OTA assessments dealing with specific technologies and/or industries, show that the U.S. lead in technology has already narrowed dramatically (and in some cases vanished). For the most part, the reasons lie in steadily improving technical abilities in other parts of the world, rather than lagging investments in U.S. R&D. But it seems plain that the United States needs to look to its technology base. In industries ranging from steel to microelectronics to automobiles, higher priorities for commercial technology development could have helped the United States deal with competitive problems. private industry did not make these investments. This suggests, in turn, that if maintaining the competitiveness of U.S. industries is to be a concern of the Federal Government, then policymakers must seek incentives for encouraging private sector R&D, as well as for diffusing the results to American companies. Analysis later in this chapter indicates that strengthening the Nation's technological advantages should be a high priority for U.S. policy makers.

[2]According to a 1977 survey, the latest available, U.S. affiliates abroad licensed to another 5,5oo affiliated foreign firms and to 4,600 unaffiliated enterprises. See *U.S. Direct Investment Abroad*, 1977 [Washington, DC: Department of Commerce, 1981), p. 166. At least 8,000 of the 24,000 overseas affiliates of [J. S. firms made use of the parent firms processes and patents-p. 1 63.

[3]E. Mansfield and A. Romeo, "Technology Transfer to Overseas Subsidiaries by U.S.-Based Firms, " *Quarterly Journal of Economics*, vol. 95, No. 4, December 1980, p. 739. Also E. Mansfield, "Market Structure, International Technology Transfer, and the Effects on Productivity of the Composition of R and D Expenditures, " final report to the National Science Foundation, 1981, p. 51, The proportion of technologies less than 5 years old (as measured by the time since first utilization in the United States) transferred to subsidiaries in developed countries increased from 27 percent for the period 1960-68 to 75 percent for 1969-78 [although no such trend emerged for technologies transferred to subsidiaries in LDCS or through unaffiliated licenses and joint ventures). Mansfield found that technologies transferred to affiliates in developed countries were much newer on the average (with a time lag since utilization in the United States of 5.8 years) than those transferred to subsidiaries in developing countries (9.8 years).

TECHNOLOGICAL ADVANTAGE AND NATIONAL STRATEGY

Has the ability of U.S. firms to compete in technologically based products really declined? There is no smoking gun, Yet a body of evidence with impressive cumulative impact supports such a conclusion, This section examines a range of indicators bearing on U.S. technology, before going onto comparisons with Japan and other nations.

R&D and Technology Development in the United States

Although resource inputs to technology development increased over the 1970s and into the 1980s, outputs decreased on several measures. Figure 39 shows that R&D spending by American companies has grown steadily in real terms, with the exception of recessionary periods in 1971-72 and 1975. Expenditures grew by more than 80 percent in real terms over the period 1975-1985 (reaching an estimated $22.6 billion in 1972 dollars, corresponding to $52.4 billion in 1985 dollars). The number of engineers and scientists engaged in R&D has increased from about 500,000 in the middle 1960s to more than 750,000 currently (a period during which R&D engineers and scientists in Japan tripled, as noted below).

Many more engineers and scientists graduated from American universities during the cyclical upswing of the 1980s than during the previous decade. Although undergraduate engineering enrollments turned back down in 1984, bachelor's and master's degrees in engineering reached record highs during the first half of the 1980s—of particular significance given that engineers and scientists play quite different roles in technology development (transfers of skills across the boundary between science and engineering can be far more difficult than the layperson might imagine]. After rapid growth during the 1960s, the number of doctoral degrees in science and engineering peaked in the early 1970s and began to slowly decline. The drop would have been more rapid—and its consequences more serious—without an influx of foreign students, particularly dramatic at the doctoral level in engineering (table 24). Although comprising only 2. 7 percent of the total student population, foreign students received 42 percent of all engineering doctorates in 1983.[4]

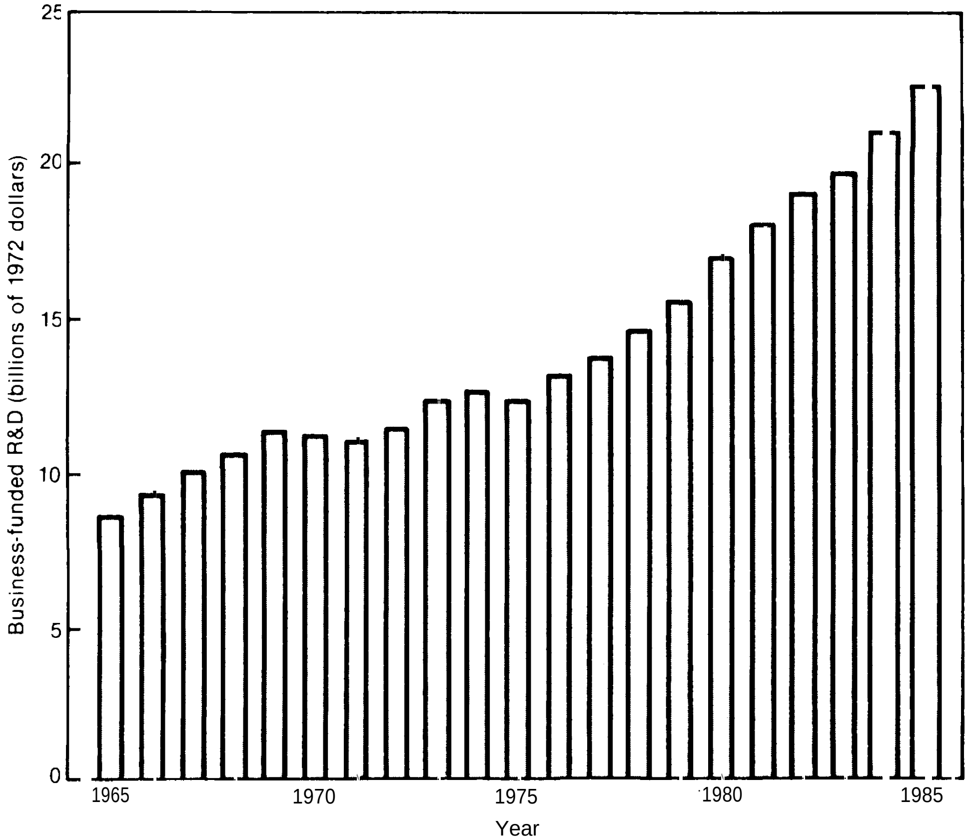
Many of these foreign graduates remain in the United States and find jobs with American corporations. In 1984, for example, 87 percent of foreign doctoral recipients with permanent visas and 49 percent of those with temporary visas chose this option, s Because they can seldom get security clearances without citizenship, more foreign-born technical graduates find their way into American companies that emphasize commercial rather than defense-related lines of business. (About 20 percent of the Nation's engineers work in defense industries .5) In fact, American industry has come increasingly to rely on foreign nationals to fill technical jobs. The proportion of the U.S. engineering work force made up of naturalized citizens grew from about 5 percent in 1972 to 15 percent a decade later, Many high-technology companies in such industries as semiconductors and computer software depend heavily on foreign-born engineers, some of whom have themselves started entrepreneurial firms; Tandon Corp., founded by Sirjang Tandon in

[4]More foreign students enroll each year in American universities (over 300,000) than in those of France (1 10,000), the United Kingdom [60,000), West Germany (50,000), and Canada (40,000) combined—S. Kahne, "Does the U.S. Need a National Policy on Foreign Students?" *Engineering Education,* October 1983, p. 54. The greatest numbers of foreign nationals in American universities come from Taiwan (22,600 in 1984-85), followed by Malaysia (21,700), Nigeria (18,400), and Iran and South Korea (both about 16,500). See *Trade in Services: Exports and Foreign Revenues* (Washington, DC: Office of Technology Assessment, September 1986), p. 64.

S"Foreign Citizens in U.S. Science and Engineering: History, Status and Outlook, " National Science Foundation, Division of Science Resources Studies, Washington, DC, January 1985, pp. 168-169.

[6]At the B.S. level, the 1984 figure for all engineers was 19.9 percent, ranging from 59,8 percent for aerospace engineers down to 16 percent for materials specialists. About 20 percent of B.S. level computer scientists, and 40 percent of mathematics majors were working on Defense Department projects in 1984, The percentages have generally declined somewhat since the Vietnam War period, and are broadly similar among engineers with graduate degrees. See *The impact of Defense Spending on Nondefense Engineering Labor Markets* (Washington, DC: National Academy Press, 1986), p. 74.

Figure 39.—Constant-Dollar Growth in R&D Spending by American Companies



NOTE 1983 preliminary; 1984 and 1985 estimated
SOURCE *Science /nd/caters* 1985 (Washington, DC National Science Board, 1985), p 252

Table 24.— Foreign Nationals Receiving Doctoral Degrees in Engineering and Science From American Universities

	Foreign nationals on temporary visas as a percentage of all doctoral recipients in engineering and science				
Field	1966	1970	1974	1980	1983
Engineering	16 70/o	13.7%	22.4%	34.3%	42.1%
Physics and astronomy	122	11,3	17,2	19,2	24,6
Chemistry	11 1	7.9	102	15,4	16.1
Mathematics	126	10,9	18,5	18,7	29.8
Total[a]	15 .3%	12 .5%	16. 7%	18.8%	15.5%

a,ncludes the following fields not sepa rately tabulated biological earth environmental agricul- tural and medica! sciences economics political science

SOURCE *Demographic Trends and* the *Scientific and Engineering WorkForce -4 Technical Memorandum* (Washington DC Off Ice of Technology Assessment December 1985) p 44

1975 to make disk drives for computers, is one of the better known examples. T"

While resource inputs to U.S. technology development show substantial increases in over the past 10 to 15 years, this growth has been neither so rapid nor so consistent as in other major industrial nations (as summarized below).

[7]0n Tandon, see C.L. Howe, "Floppy Fortunes Founder, " *Datamation*, *Nov.* 1, 1985, p. 60.

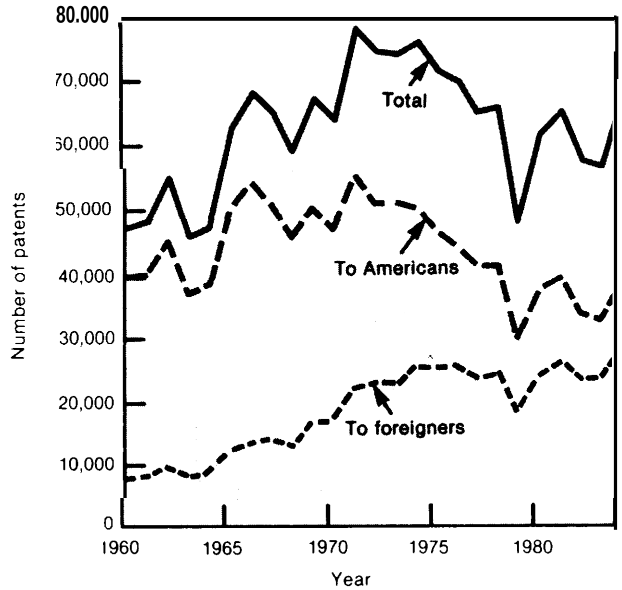
In many chemical, electronics, and computer firms, the proportion of foreign-born technical employees has risen to a quarter or more--' 'Survey of 300 U .S. Firms Finds One-Half Employ Foreign Scientists and Engineers, " NSF 85-336, National Science Foundation, Division of Science Resources Studies, Science Resources Studies Highlights, Washington, DC, Feb. 28, 1986, p. 1.

Moreover, expansion in U.S. R&D has come to depend on the willingness of foreign-born students to emigrate to this country. (American-educated engineers from South Korea and Taiwan often return home in mid-career, becoming highly productive employees of firms that compete with U.S.-based enterprises.) Finally, resources devoted to commercial technology development have not grown as rapidly as those going to defense-related R&D, which attracts many of the Nation's best technical people.

If such observations seem troubling, the data on outputs of the R&D process are more so. Although R&D outputs are much harder to measure than inputs, patents and other indicators offer proxies. Figure 40 shows that patenting in the United States by Americans has steadily declined from a peak in 1970. In contrast, U.S. patents granted to foreign parties have continued to rise.

Given the greater expenditures on R&D noted above, why should the rate of patenting by American corporations slow? (Companies, rather than individuals, file for most patents.) Two possibilities exist: declining productivity of the R&D process in the United States, and/or conscious choices by American companies not to seek patent protection. Taking the second possibility first, a recent survey of U.S. firms found more reporting an increase than a decrease in the *percentage* of developments they chose to patent.[8] All else the same, this finding of a greater propensity to patent, coupled with the drop in total patents granted, suggests that the number of patentable inventions resulting from U.S. industrial R&D has fallen. Further evidence pointing in the same direction comes from a decline in research publications by industrial employees. The number of such publications fell from 12,200 in 1973 to 10,400 in 1980, with most of the drop occurring between 1973 and 1977.[9] In sum, there is good, although

Figure 40.— U.S. Patents Granted, by Nationality of Inventor



NOTE 1979 data are spuriously low due to lack of funds in the Patent Office for printing and Issuing patents

SOURCE *Science Indicators* 1985 (Washington, DC National Science Board, 1985), p 258.

not conclusive, evidence that, despite growing investment in commercial technology development in the United States, the flow of new technologies from that effort has declined.

Foreign Technology Development

Europe and Japan

Certainly, technology development in the United States has not matched the surge abroad. Since the end of World War II, Europe and Japan have rebuilt their technological infrastructures and manufacturing capacities to the point that many companies now operate at the state-of-the-art in many technologies. As previous OTA studies have indicated, lagging international competitiveness among European firms can seldom be attributed to disadvantages in technology; the sources of competitive difficulty typically lie elsewhere, often in the translation of technology into viable commercial products.[10] Japan, in some contrast, has applied

[8] E. Mansfield, "Studies of Tax Policy, Innovation, and Patents: A Final Report," Final Report to the National Science Foundation, October 1985, p. 86. The survey covered patenting decisions over the periods 1965-69 and 1980-82 in 100 U.S. firms,

[9] The figures include all articles with at least one author from private industry in over 2,100 journals included in the Science *Citation Index* of the Institute for Scientific Information. See *Science Indicators* 1982 (Washington, DC: National Science Board, 1983), p. 296.

[10] See, e.g., *International Competitiveness in Electronics* (Washington, DC: Office of Technology Assessment, November 1983), chs. 4, 5, and 10.

Table 25.—Technical Licensing Transactions of Selected European Countries

	Balance of payments position in fees and royalties (millions of 1975 U.S. dollars)					
	1972			1982		
	Receipts	Payments	Balance	Receipts	Payments	Balance
United Kingdom	$561	$508	$+53	$608	$496	$+147
France	301	459	–158	550	641	–91
Federal Republic of Germany	269	627	–358	340	675	–335
Netherlands	151	222	–71	209	351	–142
Italy	81	470	–389	133	496	–363

SOURCE OECD *Science and Technology Indicators II Resources Devoted to R&D, Technological Performance and Industrial Competitiveness* (Paris Organization for Economic Cooperation and Development, 1985), p. 69,

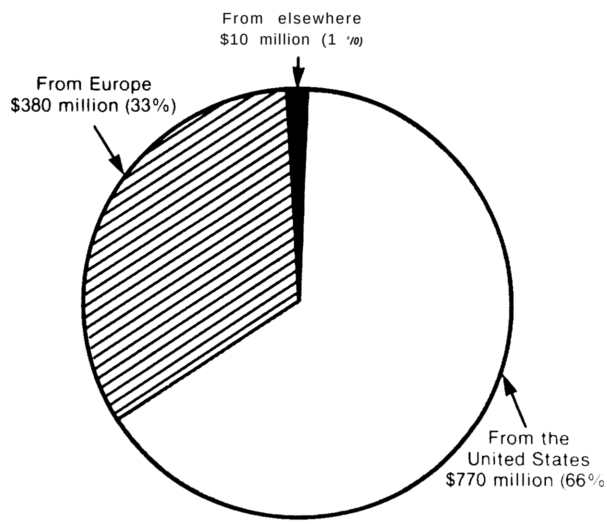
technology very effectively during its rise as an industrial power,

Both Europe and Japan have imported technical know-how from the United States, as figure 38 suggested. In Europe, inputs of American technology accompanied heavy direct investment by American firms beginning in the 1950s. Europe's technology imports continued to increase, but more rapid growth in outward licensing shows that European countries have become important sources for new technology as well. Even so, as table 25 indicates, only the United Kingdom has been a net exporter of technology. (Indeed, a bare handful of nations run a surplus in licensing transactions.)

In Japan, where government policies prevented most direct investment by American companies, the technology transfer channels differed (box V). About two-thirds of Japan's licensing payments continue to go to U.S. firms, with most of the remainder to European companies (figure 41). In Europe, affiliates of American companies account for the lion's share of U.S. licensing revenues (table 26); in contrast, arms-length transactions—those with unaffiliated firms—have predominated in Japan. Finally, while Japan's total licensing payments still exceed receipts (table 27)—reflecting old licenses—new outward licensing by Japanese companies has exceeded inward licensing since 1973 (much of this associated with FDI by Japanese companies elsewhere in Asia).

What of R&D spending in other nations? Over the period 1969-81, real R&D spending by business and industry (rather than government) in the United States grew at 4.1 percent per year,

Figure 41 .—Japan's Technology Imports, 1982



Total: 6,936 licensing agreements valued at $1 16 billion

SOURCE: *Report on the Survey of Research and Development* (Tokyo Prime Minister's Office, Statistics Bureau, 1983), p 44

less than half the rate (8.6 percent) in Japan.[11] Today, business and industry in Japan spend more on R&D than in any other country except the United States—table 28. While the rate of growth of business spending on R&D in current dollars has been slightly greater over the

[11] *OECD Science and Technology indicators II: Resources Devoted to R&D, Technological Performance and Industrial Competitiveness: Annex* (Paris: Organization for Economic Cooperation and Development, 1985), table 4. Over the 1969-81 period, the real annual rates of growth in business-funded R&D averaged 5.4 percent i n West Germany, 5.5 percent in Fra rice, but only 2.0 percent in Britain. The figure for the European Economic Community as a whole comes to 4.5 percent, and for the Organization for Economic Cooperation and Development, 5.o percent.

Box V.—Have U.S. Firms Licensed Their Technology Too Cheaply?

American technology helped fuel postwar economic growth in both Europe and Japan. In Europe, American technology accompanied American investment, but the Japanese Government followed a strategy of restricting direct investment. With government policies also limiting goods imports, and Japanese companies aggressively seeking foreign know-how, American companies supplied Japan with a great deal of technology under arms-length licensing agreements. Only in the late 1960s did Japan begin opening its economy to foreign investment and imports; after 1967, majority foreign ownership in new Japanese companies was permitted in some industries, with entry into others liberalized later. As table 26 indicates, U.S. companies continue to receive substantially more in royalties and license fees from unaffiliated firms than from affiliates in Japan. In contrast, affiliates account for 80 percent of payments from Europe.

Between 1950 and 1980, Japanese firms entered into more than 30,000 technology transfer agreements with American companies, for which they paid an estimated cumulative total of $10 billion.[1] With remarkable speed, Japanese companies moved from commodity goods and simple consumer products to high-technology manufactures, including computers and integrated circuits that often match or exceed the best products of American firms. Today, many Japanese companies continue to pay royalties on technologies they have long since adapted and improved upon.

Hence the claim that, into the 1970s, American companies sold technology to Japan too cheaply. The implication is that an appropriate price for a given package of technology exists, and that, for one reason or **another, bargaining processes between** U.S. **firms and potential licensees in Japan failed to identify it. In essence, the underpricing argument suggests that U.S. companies took an overly simple approach to licensing decisions-that they considered their technology development expenses as sunk costs, with licensing revenues desirable as extra returns. Because they underestimated the ability of Japanese manufacturers to challenge them in the U.S. market and in third countries, American companies accepted royalty rates that were too low.**

As **this suggests, the question of possible underpricing of technology can be discussed on several levels. Normally, an American firm with proprietary technology will assess the possibilities for exploiting its know-how internationallly, with an eye to maximizing profits. In Japan, government restrictions barred both U.S. exports and FDI. Given these constraints, licensing might seem the best—indeed only-choice, on the basis that some return from the Japanese market is better than none. But what of the royalty to be charged? How should it be set? From the licenser's point of view, almost any royalty rate might be acceptable, since the R&D had already been paid for. But plainly, such a calculation depends on the absence of future competition based on the transferred technologies.** If American managers had foreseen that Japanese manufacturers would enter U.S. markets, and compete with them for export sales in third countries, they should have demanded higher royalties. In the extreme, they might have refused to license at all.

In any case, Japanese companies learned very quickly to innovate on their own; the stream of new products in consumer industries beginning during the early 1960s shows this quite convincingly, as does the unquestioned technical competence of Japanese firms in industries like iron and steel productions Help from American companies was useful but seldom essential, and, in later years, only rarely went beyond that available from Europe. If licensing saved the Japanese time and money, American firms benefited from revenues that they could invest in their own operations—earnings that, for U.S. industry as a whole, have approached $1 billion annually in recent years (table 26). Finally, even with hindsight, the consequences of particular licensing arrangements often remain ambiguous. In 1960, when Japan's Government permitted IBM to begin local production of computers,

[1] **J. Abegglen,** "U.S.-Japan **Technological** Exchange in **Retrospect,** 194S-1S81," ***Technological*** *Exchange:* ***The U.S.-Japanese Experience, C.*** **Uyehara** (cd.) (Washington, DC: University Press of America, 1SS2), **p.** 1.

[2] **For** one of the most **fully** documented recent accounts, **focusing** on manufacturing technology **as well** as product development, aae **M.A. Cusumano,** ***The Japanese Automobile Industry: Technology and Management at Nissan and Toyota*** (Cambridge, **MA:** Harvard University **Press,** ***1985).***

the price included licenses for Japanese companies. IBM-Japan quickly gained the lead in the Japanese computer market; although overtaken in sales during the first half of the 1980s by Fujitsu and NEC, IBM still has the largest installed equipment base in Japan. Both the Japanese companies benefited to at least a modest extent from IBM's licensing. But if IBM had not granted these licenses, the company probably would not have been permitted full-scale entry into Japan's computer market until the liberalization of the 1970s, by which time its rivals' installed bases would have presented a severe obstacle to market penetrations

Today, most American firms would claim to take considerable care in negotiating license agreements to prevent future damage to their own interests—and more care today than in earlier years. Where once they licensed their microprocessor designs to Japanese firms, American manufacturers—who remain well ahead in this technology—now refuse to do so.[4] In OTA's interviews, American managers expressed a clear sense of the strategic risks involved in licensing in Japan (or to newly industrializing countries, particularly in the Far East). But their evaluations-whether of isolated arms-length agreements, or of complex strategic options in which licensing is one part of a carefully designed thrust into overseas markets—will be couched in terms of their own interests, and to a lesser degree those of their industry, their suppliers, their customers. The bigger picture of U.S. competitiveness will more than likely remain outside their calculations.

When it comes to tightly written licensing agreements recent shifts in antitrust enforcement by the Federal Government make things easier for American companies. Managers express considerably less concern than half a dozen years ago over possible antitrust litigation, given that the Department of Justice has sent enough signals to convince even the more conservative corporate legal advisers that restrictive licensing provisions, once subject to challenge as anti-competitive, will be viewed more tolerantly in the future (seethe section on "Policy Issues" later in the chapter). Companies now feel free to negotiate agreements barring their licensees from a wider range of activities that might pose direct competitive challenges.

In the end, the original question—whether U.S. firms licensed their technology too cheaply–seems less significant than the question of how the United States can begin to learn more effectively from Japanese technology. Regardless of the extent to which Western technologies helped Japan reach early technical maturity, the fact is that in the future the United States will have to depend as heavily on Japanese technology as Japan depends on the United States. U.S. licensing payments to Japanese companies have been steadily increasing, with about a fifth of all U.S. payments now going to Japan. Rather than seeking to stem technology outflows, U.S. policymakers might make equal access to foreign technology a negotiating objective in trade talks, fund fellowships for American students in engineering and science to work in Japanese laboratories, and seek exchanges of U.S. industrial R&D personnel with those of Japan (and other countries). (Ch. 10 includes specific policy options.) Direct participation by Americans in overseas industrial R&D will speed U.S. access; people transfer technology much more effectively than documents. It is time for Americans to go overseas in search of technology as frequently as foreigners come here.

[3] *International Competitiveness in Electronics* (Washington, DC: Office of Technology Assessment, November 1983), p. 154.

[4] This refusal is one reason for a new agreement between Fujitsu and Hitachi to jointly develop a family of 32-bit microprocessor designs, See S.K. Yoder, "Hitachi, Fujitsu Link in Microprocessors," *Wall Street Journal*, Oct. 28, 1988, p. 39.

past 5 years in the United States, if adjusted for inflation, growth would be considerably more rapid in Japan. Furthermore, the overall lead of the United States stems from nothing more than the greater size of the U.S. economy.

In Japan, industry now accounts for more than three-quarters of all R&D spending, compared with about half here, while business-funded R&D as a percentage of gross domestic product (GDP) is much higher in Japan. As indicated in table 1 (ch. 1), business and industry in Japan spent (a projected) 2.14 percent of GDP on R&D in 1986, compared with 1.42 percent in the United States. As table 1 also showed, in the early 1970s, this ratio did not differ greatly among the United States, Japan, and West Germany. Around the middle of the dec-

Table 26.—U.S. Technical Licensing With Europe and Japan (millions of current dollars)

	Affiliated	Unaffiliated	Total
U.S. receipts of royalties and license *fees* from Western European companies:			
1978	$1,482	$448	$1,930
1980	2,019	476	2,495
1983	2,355	628	2,983
1984	2,467	604	3,071
1985	2,657	634	3,321
U.S. receipts of royalties and license fees from Japanese companies:			
1978	*$273*	*$399*	*$ 612*
1980	—[a]	*347*	NA
1983	392	523	915
1984	449	549	998
1985	476	576	1,052

NA = Not available
[a]Data suppressed by Department of Commerce to preserve confidentiality
NOTE 1983-85 data are not directly comparable with that for earlier years because of a new benchmark survey and the inclusion of non-manufacturing royalties and fees beginning in 1983
SOURCES 1978, 1980 Department of Commerce, Bureau of Economic Analysis, unpublished statistics 1983-85 R C Krueger "U S International Transactions First Quarter 1986 ' Survey *of Current Business,* June 1986, pp 64-65

ade, however, both Japanese and German companies began increasing their R&D spending at higher rates. The increase in Japan since 1980 has been especially dramatic. Everything else the same, the figures in table 1 demonstrate that Japanese and also West German companies have placed substantially higher priorities on R&D than their American counterparts; the *very high rates of R&D spending by Japanese companies over the past 3 years demonstrate their intent to move even more rapidly into high technology.*

Trends in employment of R&D engineers and scientists paint a similar picture, Since 1965, the number of engineers and scientists has increased steadily in the United States, as well as in Japan and in West Germany, Britain, and France. In 1981, the last year for which data are available for all five countries, the United States employed more R&D personnel than Japan and the three major European economies combined.[12] While impressive, this represents a much smaller differential than existed in 1965, when about twice as many people worked in R&D in the United States as in the other five countries. Indeed, the number of R&D personnel in the United States actually declined during the early 1970s. U.S. R&D employment passed its earlier peak by 1977, but none of the other countries passed through such a slump.

One further input measure stands out as having grave implications for the future: the number of engineering graduates. Japanese universities have been awarding more engineering degrees at the bachelor's level than have American schools—74,()()() in 1982 compared with 67,000 here.[13] Six engineers graduate in Japan for every scientist; in the United States, 1.4 science majors graduate for every engineer. Although engineers and scientists share many

[12]*Science Indicators: The 1985 Report* (Washington, DC: National Science Board, 1985), p. 186, The 1981 figures are: United States, 691,000; Japan, 318,000; Germany, 128,000; Britain, 96,000; France, 85,000. By 1983, the U.S. figure was 750,000, and that in Japan, 342,000,

[13]*Science Indicators: The 1985 Report,* Op. cit., p. 6. The number of engineering bachelor's degrees awarded in Japan has grown steadily from 10,000 in 1955—1,.S. Hiraoka, "Japan's Technology Trade, " *Technological Forecasting and Social Change,* vol. 29, 1985, p. 237. For the data on engineering graduates compared to science majors, below, see *international Science and Technology Data Update 1986,* NSF 86-307 (Washington, DC: National Science Foundation, 1986), p. 28.

Table 27.—Japan's International Technical Licensing

	Outward licensing			Inward licensing			Net receipts	
		Value			Value		Value	
	Number of agreements	(Billions of yen)	(Millions of dollars)	Number of agreements	(Billions of yen)	(Millions of dollars)	(Billions of yen)	(Millions of dollars)
All *Japanese technology exchange* **agreements in force:**								
1978	3,157	122,0	$620	6,573	192.1	$ 985	– 70.1	$–359
1980	4,103	159,6	786	7,248	239.5	1179	– 79,9	– 394
1982	4,738	184,9	760	6,936	282.6	1162	– 79,7	–402
New *Japanese technology exchange contracts:*								
1978	1,063	47,1	$242	936	38.2	$ 196	8.9	$ 46
1980	1,237	74,3	366	919	27.7	136	46.6	230
1982	1,970	63.3	260	929	44,4	183	18,9	78

SOURCE *Report on the Survey of Research and Development* (Tokyo Prime Minister's Of fice, Statistics Bureau, 1983) p 42

Table 28.—R&D Funded by Business and Industry

	Business-funded R&D expenditures (billions of current dollars, yen, or deutsche marks and percentage of total national R&D spending)				Average annual rate of growth, 1981-86 (percent)
	1981	1983	1985	1986a	
United States;					
Billions of dollars	$35.9	$43.2	$53.2	$58.2	1o.1"/0
As percentage of all U.S. R&D	50.0 "/0	50.0 "/0	49.9%	49,80/o	
Japan:					
Billions of yen	4,364	5,451	6,500	7,000	9.9%
Billions of dollars[b]	$19.8	$23.0	$27.5	$42.9	
As percentage of all Japanese R&D	72.90/o	75.9 "/0	77.4 "/0	77.80/o	
Federal Republic of Germany:					
Billions of deutsche marks	22.5	26.0	30.0	32.5	7.6 '/o
Billions of dollars[b]	$10.0	$10.2	$10.3	$14.9	
As percentage of all West German R&D	54.90/0	56.6%	57.6 "/o	58.80/o	

[a]Projected
[b]Conversions t. dollars for year In question from *Economic Report of the President* (Washington DC U S Government Print in g Of flee February 1986) p 373 except for 1966 where mid-year values have been used

SOURCE FRG Institute Compares German U S Japan Research Expend itures, " *Europe Report—Science and Technology* Joint Publications Research Service JPRS-EST-86-033. Nov 6, 1986, pp 25, 28, 31 Translated from *Technologie Nachrichten* May 15 1986 Original source Battelle Institute, Frankfort

skills, product/process design and development —the heart of an industrial R&D operation—is work for which engineers are trained and scientists are not. The quality of engineering education in Japan is distinctly inferior to that in the United States, but in numbers—given that Japan has, for more than a decade, been graduating twice as many engineers per capita—it would be hard to fault that country's performance.[14]

What have been the impacts of increased inputs to the R&D process in other countries? Patent applications have fallen in the major European nations (table 29), just as they have in the United States. The implication, again as here: declining technological productivity. The case is different for Japan, where companies seem to have a much higher propensity to patent (in part because patents are awarded on a first-to-file basis, rather than first-to-invent). This makes international comparisons of patenting problematic. Even so, the steep rise in domestic patent applications in Japan—they have more than doubled since 1970, while patenting in other countries has declined—probably indicates a significant increase in the output of Japanese R&D.

Because patents are only valid in the country granting them, a company seeking to protect its technology must obtain patents everywhere it seeks either to use an invention or to prevent competitors from doing so. Therefore, external patenting—filings by residents of one country in another—become another possible measure of R&D proficiency. Securing adequate protection can be expensive, particularly where multiple patents must be sought to lock up a new development. Because company managements approach such decisions with care, data on external patents provide a useful indicator of the commercial value businesses place on their technical innovations. These data—table 30—show that American companies file the greatest number of external applications. But the figures also show that the number of U.S. applications fell sharply during the 1970s, before recovering in recent years,

The pattern is similar for Western Europe, but not Japan, where companies have filed

[14]Major Japanese corpora t ions ha ve been fore ed t o develop extensive internal training programs to compensate for the shortcom i ngs of Ja pans engineering schools. See *In ternational Competitiveness in Electronics, op. cit.,* pp. 314-317.

Other count ries graduate engineers in much smaller numbers than Japan or the United States.

Table 29.—Patent Applications by Domestic Residents (thousands)[a]

	1950	1960	1970	1975	1980	1981	1982	1983
United States	57.4	63.1	76.2	64.4	62.1	62.4	63.3	59.4
Japan	14.5	31.9	100.5	135.1	165.7	191.6	210.9	227.7
Federal Republic of Germany	31.8	36.5	32.8	30.2	30.6	30.3	31.1	32.1
France	16.2	14.5	14.1	12.1	11.1	11.1	10.8	11.2
United Kingdom	21.0	*22.8*	*25.2*	*20.8*	*19.7*	*20.9*	*20.6*	20,0
Total[b]	178.0	200.6	287.7	299.6	309.3	329.6	350.5	364.5

[a]This table is based on adjusted statisticsoriginally compiled by the World Intellectual Property organization (WI PO) from reports of national patent offices The introduction of the European Patent Convention (EPC) system in 1978 and, to a lesser extent, the Patent Cooperation Treaty (PCT) system in 1970, has made it easier for companies to obtain patent protection in multiple countries Under the EPC, a firm can fi le a single application covering some or all of the (European) member na- tions As companies switched to the EPC system, patenting in the national offices of some of the member countries declined To correct for this effect, the WIPO statistics have been augmented by EPC "designation" and PCT data for years after 1978 This adjustment raises external patenting levels for the post-1978 period significantly above the unadjusted levels published in *Science Indicators*

[b]Includes Belgium, Switzerland, Australia, Yugoslavia,Denmark, Norway, Greece, Finland, Portugal, New Zealand, Ireland, and Iceland, as well as the countries listed separately

SOURCE" *OECD Science and Technology Indicators II: Resources Devoted to R&D, Technological Performance and Industrial Competitiveness:* Annex (Paris' Organization for Economic Cooperation and Development, 1985), table 24

Table 30.—External Patent Applications by Nationality of Applicant (thousands)[a]

	1950	1980	1970	1975	1980	1981	1982
United States	34.5	74.1	123.7	93.0	116.3	127.0	123.2
Japan	—[b]	3.0	26.6	27.7	45.5	49.3	56.4
Federal Republic of Germany	13.3	47.3	70.1	60.8	82.6	82.6	79.5
France	11.6	16.2	24.4	23.4	33.0	31.4	34.7
United Kingdom	20.5	29.1	33.5	24.4	28.1	31.2	33.2

NA = Not Available.
[a]Filings i, countries other than that in which the applicant resides. Adjusted statistics, as explained In table 29, footnote a
[b]Negligible.

SOURCE: *OECD Science and Technology Indicators II: Resources Devoted to R&D, Technological Performance and Industrial Competitiveness: Annex* (Paris" Organization for Economic Cooperation and Development, 1985), table 24.

steadily increasing numbers of external applications. (The establishment of the European Patent Convention in 1978 made patenting across countries in Europe easier, bringing a sharp rise in external patenting. Under the new system, a firm can file a single application that covers some or all of the European member countries.) For the United States, the data in table 30 are rather more encouraging than other indicators, in that they suggest strong and continuing commitment to international business by American firms. Yet the data also show a marked increase in external patenting by Japanese firms; more recent figures, if available, might well show that Japan has now surpassed West Germany in external patenting.

Newly Industrializing Asian Countries

Japan, the first industrial power to emerge in the Far East, has been followed by South Korea, Taiwan, Singapore, and Hong Kong. While each has pursued its own developmental path, all have been somewhat akin to Japan in first concentrating on apparel and other labor-intensive goods before branching into more capital- and skill-intensive industries. Today, some of these countries, notably South Korea, manufacture integrated circuits not far behind the state-of-the-art and enjoy expanding shares of the U.S. market for automobiles, personal computers, and a variety of computer peripherals. Moreover, as noted in chapter 4, Korean engineering and construction teams went into the Middle East more than a decade ago, winning contracts from European and American firms. In Taiwan as well as Korea, the government has stepped up support for education and training of technicians, engineers, and scientists.

Like Japan, the newly industrializing countries (NICs) in Asia have licensed technology from American companies (table 31). But, while U.S. receipts for royalties and license fees from

Table 31.–U.S. Technical Licensing With Newly Industrializing Asian Countries[a]

	U.S. receipts of royalties and license fees (millions of current dollars)		
	Affiliated	Unaffiliated	Total
1978	$ 39	$ 70	$109
1980	66	103	169
1982	67	166	233
1983	99	190	289
1984	121	203	324
1985	115	218	333

[a]BEA's categories "developing countries, other" for 1978-82 and 'other countries in Asia and Africa" for 1983-85, both of which exclude Latin America and therefore reflect primarily licensing with Asian NICs. Licenses in manufacturing only for 1978-82, all industries for 1983-85

SOURCES 1978-82. Department of Commerce, Bureau of Economic Analysis, unpublished statistics, January 1966 (Table 6C: U S. Receipts of Royalties and Licensing Fees in Manufacturing by Area). 1983-85 R C Krueger, "U. S International Transactions, First Quarter 1986, " Survey *of Current Business*, June 1986 p 66

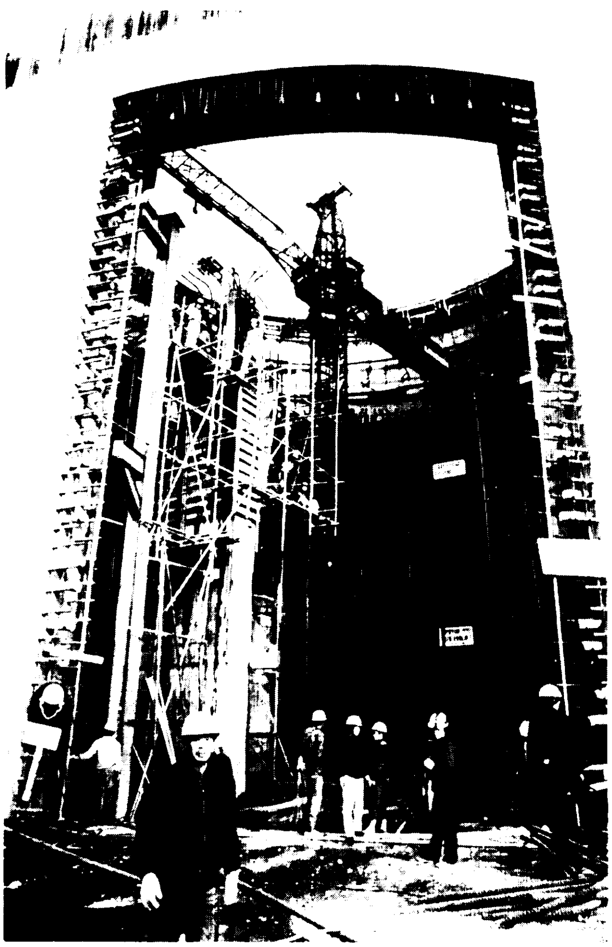


Photo credit: Bechtel Power Corp.

Cooling tower for nuclear powerplant under construction in South Korea.

the Asian NICs have been growing at a high rate, they still account for no more than 7 percent of the U.S. total, Japan has also been a major source of technology for the rest of Asia, with many licensing deals involving affiliates of Japanese companies. At the same time, Japanese firms have been notoriously reluctant to license technology to independent firms in countries like South Korea that are seen as potential rivals.[15] One of the best-known cases has been the adamant refusal by Japanese firms to license video-cassette recorder technologies to Korea. The Koreans developed their own. Japanese steelmaker also raised strong objections to licensing technology for the expansion of South Korea's steel industry. While both South Korea and Taiwan have set out on a path in electronics much like that Japan followed—first consumer products like TVs, then semiconductors and computer equipment—Hong Kong and Singapore have put relatively more emphasis on software.

The unanswered question is whether or not the Asian NICs will continue to expand their indigenous technological capabilities at a rate that would eventually challenge other industrial nations. To do so, the NICs would have to overcome the limitations imposed by small domestic markets, along with growing trade friction and import barriers in countries to which they sell. None of the NICs has been able to strengthen its science and technology infrastructure as rapidly as Japan did during the 1960s; although technical people have been returning to South Korea and Taiwan from overseas in mid-career, all the NICs remain short of engineers and scientists. They spend far less on R&D than the advanced nations. Both domestic and external patenting levels remain

[15]M. Schrage, "(Korean) Electronics Industry Seeks Leading Edge, " *The Washington Post*, Feb. 9, 1986, p. F1. Also, M.C. Harris, "Japan's International Technology Transfers, " paper prepared for presentation at Southeast Region Japan Seminar, Apr. 20, 1985, p. 15.

Still, Japan accounted for 55 percent of more than 3,000 licenses arranged by Korean companies between 1960 and 1984—B, Wysocki, Jr., "Weak in Technology, South Korea Seeks Help From Overseas," *Wall Street Journal*, Jan. 7, 1986, p. 1.

low.[16] For all these reasons, sustained technological challenges from the NICs appear to be a long way off. At the same time, these countries have a sound base in a wide range of relatively standardized technologies already, and seem bound to continue doing well with relatively routine products in quite a wide range of industries. Perhaps their greatest future handicap will simply be that they must compete with Japan.

[16] *1982 Statistic] Yearbook* (New York: United Nations, 1985), table 72. Patenting by residents of the four Asian NICs probably represents less than 1 percent of all foreign-origin U.S. patents —"All Technologies Report, 1985, " Department of Commerce, Patent and Trademark Office, Washington, DC, p. Az.

LICENSING STRATEGIES

Integration

Increasingly, American companies view technical licensing as an integral part of their business strategies. Licensing has always been an alternative for exploiting proprietary technology internationally. But most companies would choose when possible to maintain a tight hold over their technical know-how by using it to produce for export, or transferring it to controlled subsidiaries abroad. Today, these choices may be less practical than in years past. When circumstances foreclose possibilities for exports or foreign investment, companies stand to recoup at least some of their development costs through licensing. The firm may be able to earn an incremental return in markets that it otherwise could not enter at all—for reasons ranging from its own resource limitations to foreign government barriers. The situations that follow are typical:

1. If trade barriers, small market size, or management's lack of familiarity with overseas markets foreclose exporting from the United States, licensing a foreign company to make and sell products can provide a means of testing the foreign market for later investment. Caterpillar Tractor, for example, often used technical licensing as a precursor to eventual expansion abroad.
2. Small companies typically face constraints on overseas operations stemming both from financial requirements and limited managerial experience. Even when they can afford to invest abroad, many smaller American firms report that they can't find the management talent to expand. Probably for this reason, smaller companies are more likely to license than larger, integrated firms with a broad range of internal resources to draw on. In interviews, several executives from small, fast-growing computer firms cited managerial overload as a primary reason for weighing foreign involvements carefully.
3. Foreign governments may combine import barriers with investment restrictions (including performance requirements that require high fractions of local value added, local hiring, or re-exporting), forcing companies to seek alternatives.[17] As pointed out above, Japan barred foreign investment during the earlier postwar period, while the Ministry of International Trade and Industry (MITI) carefully monitored inward licensing. Today, a number of Asian and Latin American nations emulate this approach.
4. The U.S. Internal Revenue Service requires that MNCs allocate R&D expenditures between parent company and subsidiaries. Managements sometimes choose to formalize this requirement through licenses, even though no operational need exists.

This list covers only a few examples from the wide variety of circumstances that can lead companies to choose licensing as a way of doing business abroad. Generally speaking, foreign market uncertainties, which raise the risks

[17] On foreign government Policies and laws covering licensing, see J.D. Frame, "Political Risk in International Technology Transfer," *Journal of Technology Transfer,* vol. 10, 1986, p. 5.

of direct investment, make licensing more attractive to managements. Such uncertainties can have many sources: erratic government policies, foreign exchange volatility, lack of information and experience.

The appeal of licensing also depends on the nature of the technology in question. Most firms shy away from licensing their core technologies—those on which their primary lines of business depend—to unaffiliated foreign firms. Licensing always carries risks of disclosing knowledge to unauthorized parties; sometimes the licensee attempts to evade restrictions in the contract, perhaps using the technology surreptitiously. Because policing agreements is always a problem, managements seldom take chances with critical know-how. On the other hand, a firm that occupies a long-established competitive niche may well trade even state-of-the-art technologies with others that specialize. Or, a smaller company in a fast-moving industry may simply be unable to exploit every opportunity that comes along. Both factors are at work in industries like pharmaceuticals, where international licensing between competing firms has been common.

Box W amplifies on the circumstances under which American firms license overseas. In most industries, mature technologies tend to be licensed relatively freely, but maturity is a function of the pace of change in the industry. New developments in electronics—e.g., microcircuit designs—are licensed quickly because managers know that ongoing R&D will render them obsolescent in a relatively short time. If the company is not in a position to exploit these developments immediately, licensing may help defray part of the R&D costs.

Of course, licensing agreements themselves require management oversight; licensees or joint venture partners must be screened, deals evaluated, agreements negotiated. Once in place, the licensee's operations must be monitored; unsatisfactory performance can harm the licenser's reputation, perhaps threatening later opportunities for exploiting the technology. Companies go slowly when getting into licensing for the first time. Still, the managerial demands tend to be far less than for an initial foray into exporting or overseas manufacturing,

As noted in box W, cross-licensing agreements—where firms agree to share each other's developments—have become increasingly common, Royalties may or may not be involved, depending on the match between firms in terms of development capability. OTA interviews indicate that more and more license agreements involve two-way flows of technology. A significant proportion of licensing in the pharmaceutical industry, for example, is done on a quid pro quo basis—i.e., one technology for another. particularly in industries where few companies can afford to stay abreast of all relevant technologies, exchanging R&D results helps both parties. Companies can target their efforts on quite specific needs, getting complementary knowledge elsewhere.

The growing number of international cross-licensing agreements illustrate one way in which corporate managements have begun using licensing for strategic purposes. As companies seek to control and apply technical knowledge to reap longer term rewards, licensing becomes increasingly integrated into the broader strategic view of upper level managers. For example, in earlier years, when countries like Japan closed their markets to exports or FDI, American companies frequently licensed unaffiliated companies to manufacture and market products locally, subject only to the usual royalty arrangements. Today, the impacts of such licenses on other aspects of the firm's domestic and international business get much more attention. An MNC might seek to tie new agreements to the purchase of components which themselves contain proprietary, but not licensed, technologies (e.g., a microprocessor chip set). In this way, the MNC assures continuing product exports, while also controlling the licensee's use of the transferred technology. Some know-how might be licensed, with related information held back. A communications equipment manufacturer might license a foreign firm to produce fiber-optic cable on the condition that connectors and amplifiers be imported. In a very real sense, the licensee

Box W.-Who Licenses and Why?

Many of the larger firms from the Fortune 500 list have hundreds, even thousands, of overseas licensing agreements in force.[1] Manufacturing companies, of one sort and another, account for the vast majority of the Nation's outward licensing (figure 42], with most of the rest involving companies that conduct R&D as a business-not only contract research firms, but new research-based enterprises that have not yet reached the stage of manufacturing. Figure 42 gives the distribution by industry of parent firm for U.S. licensing receipts (affiliated plus unaffiliated) in 1982. Manufacturing accounted for 93 percent of the total, with two industries responsible for more than half of all receipts-chemicals (including pharmaceutics] and machinery (much of which consists of office and computing machines, although no breakdown is available). Electrical machinery, which includes electronic components, accounts for another 13 percent.

As pointed out below, a number of biotechnology startups have licensed quite actively overseas-to generate needed flows of cash from their research, or to trade technology for capital. Often they cannot afford the scale-up and marketing expenses needed to utilize the-knowledge flowing from their R&D. A few American companies develop technology solely for license-e.g., process technologies for the petrochemical industry. Occasionally, individual inventors license their patents. Licensing has always been more common in research-intensive industries, where many companies count on licensing revenues to help pay for ongoing R&D. Figure 43 shows that, on average, licensing receipts cover more than a quarter of the R&D expenses for U.S. firms in the machinery industry; the fraction is probably somewhat higher for office and computing machines.

In the pharmaceutical industry, about 20 percent of all new products introduced stem from licensed technologies rather than internal developments. High product development costs mean that, worldwide, perhaps 20 to 30 large companies have been able to keep up across a broad front. Many smaller firms routinely license to larger companies with more resources for bringing new products to market. The patterns, of course, are not static: some companies, like Marion Laboratories, that once licensed all their new technologies from outside firms have now begun internal product development programs; others, such as Lilly, still neither buy nor sell technology.

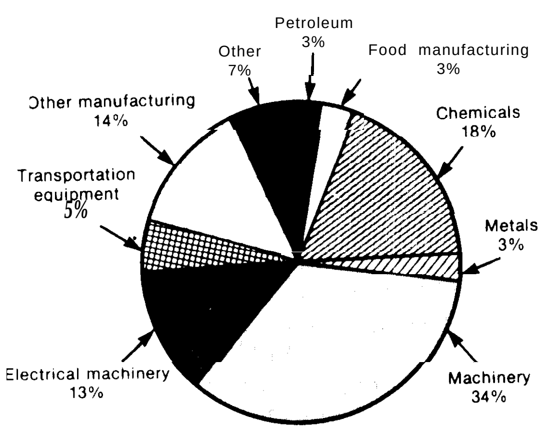
Conditions in a particular industry may, in essence, force a company to license. Most semiconductors are sold to companies making products like computers and communications equipment. When major customers insist on multiple sources of supply, an innovator may have little choice but to license a new integrated circuit design to competitors.[2] To sell to foreign customers may mean licensing foreign competitors. Ac-

[1] F.J. Contractor, *International Technology Licensing: Compensation,* Coats, *and Negotiation* (Lexington, MA: Lexington Book 1981), pp. 57, 96.

[2] In recent years, formalized alternate sourcing agreements have largely (but not completely) replaced the copying that wee once so frequent in this industry. See, for example, "Trade Ethics in Silicon Valley," New York *Times*, June 25,1082, p. D1; F.C. Klein, "'Reverse Engineering Of Microchips Is Slow, Costly—and Universal," *Wall Street Journal*, Aug. 5, 1982, p. 1; M.W. Miller, "Intel Charges NEC Illegally Copied Microchip Designs," *Wall Street Journal*, Feb. 27, 1985, p. 28.

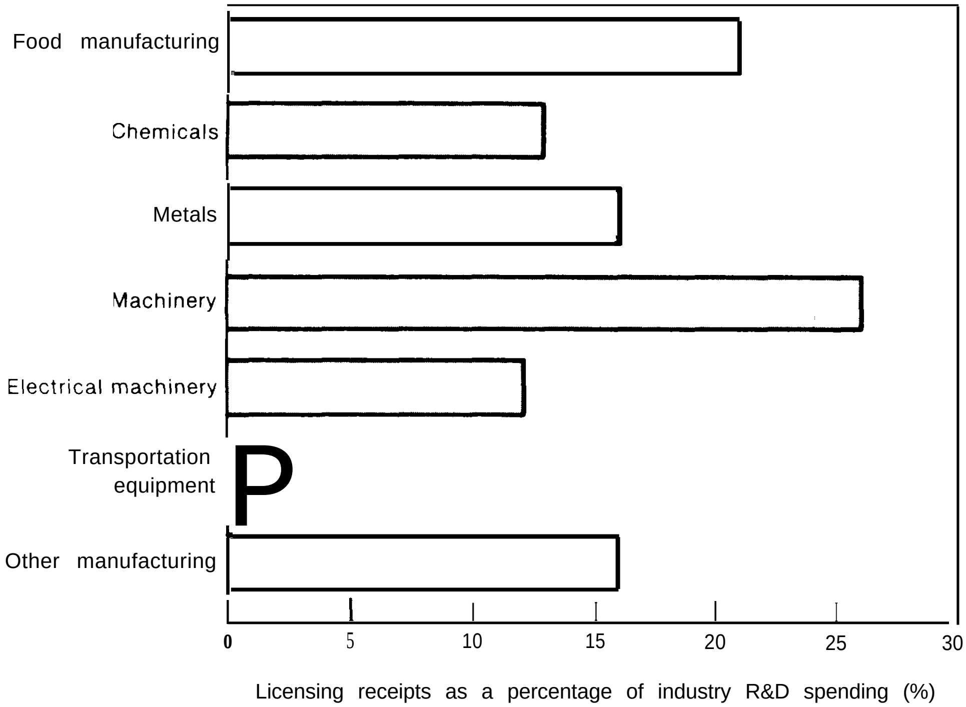
In other industries, particularly them relying on proprietary manufacturing techniques, reverse engineering may be impossible. Given a complex macromolecule—e.g., a polymer or genetically engineering organism—there arm way to deduce with certainty how it might have been produced. The more process steps, the more difficult it is to work backwards.

Figure 42.-U.S. Receipts of Royalties and Fees by Industry, 1$82



SOURCE: *U.S. Direct Investment Abroad: 1982 Benchmark Survey* (Washington, DC: Department of Commerce, 1985), pp. 338-339.

Fiqure 43.— Royalties and Licensing Fees As a Percentage of R&D Spending in U.S. Manufacturing Industries, 1982



SOURCE U S *Direct Investment Abroad 1982 Benchmark Survey* (Washington, DC Department of Commerce 1985) pp 338-339

tive assistance to second-sources may help the innovator establish its design in the marketplace. Indeed, second-sourcing is one of the few cases in which an electronics company might license so-called trade secrets. In the extreme, it may be the only way to capitalize on a new design; that is, the innovating company may have to help its competitors get into production in order to sell at all. Given the way the semiconductor market operates, companies may also cooperate in developing the members of a family of chip designs. In such industries—where the pace of technical development is rapid, and markets volatile and hard to predict—arrangements involving licensing, cross-licensing, second-sourcing, and joint product development function as risk-sharing mechanisms. Managers may choose a reduced share of a more certain market, particularly a rapidly growing market, rather than chance going it alone.

Cross-licensing, in particular, offers further examples of risk-spreading. In industries such as computers and microelectronics, many companies have opted for cross-licensing—usually covering patented technologies only—with almost any firm, domestic or foreign, capable of generating knowledge comparable to its own. One reason is simply to gain access to technologies that can help in filling out product lines. But why should potential competitors agree in advance to share all patents? According to OTA's interviews, perhaps the most important reason is simply to avoid having to perpetually monitor possible patent infringements all over the world; executives in one company stated that, without wholesale cross-licensing, they would be engaged in lawsuits nearly everywhere. By the same token, they avoid worrying about infringing others' patents.

Litigation can nonetheless follow if cross-licensing relationships break down. Early in 1986, Texas Instruments (TI) filed process patent infringement suits against eight Japanese and one Korean firm for selling random access memory (RAM) chips without licenses under TI patents. According to TI, the nine companies had been licensed in the past, but the contracts had expired and negotiations for renewal had not been completed; a company spokesman suggested that the suit might speed progress toward new agreements.[3] TI asked the U.S. International Trade Commission to recommend that imports of RAM chips as well as downstream products using them, including mainframe computers, be banned from U.S. markets. In response, one of the Japanese companies, NEC, filed a patent infringement suit in Tokyo against TI-Japan, while another filed a patent infringement counterclaim against TI in the United States. Some of these cases have now been settled; others remain unresolved.

Like semiconductor manufacturers, new biotechnology firms have often found themselves forced to license, but for different reasons. These firms may have a competitive advantage in drawing on the pool of research results in genetic engineering, but face difficulties in commercialization. Not only is substantial investment capital often required, but so is a broad range of scientific and technical expertise. Scale-up from laboratory batches to commercial production has been a common problem; regulatory approvals may pose an unfamiliar set of hurdles. Under such circumstances, a relatively small biotechnology firm may simply find itself stretched too thin; it might seek partners, consider contracting with another company to undertake manufacturing, or it may license. Under such circumstances, a foreign partner maybe more attractive because the originator can retain the U.S. market for itself. Further, because of Food and Drug Administration regulations prohibiting exports of new drugs before they have been approved in the United States, a foreign firm maybe able to get approvals and introduce the product more rapidly overseas.

'*Electronic News,* Mar. 17, 1986, pp. 38-41; "Texas Instruments Reports on Company's Improvement Into First Quarter of 1986," *PR Newswire,* Apr. 17, 1966; P. Duke, Jr., "Patent Lawsuits Against Sharp, Fujitsu Settled," *Wall Street Journal,* Jan. 12, 1987, p. 8.

can become integrated into the MNC's own global operations.

Still more complicated examples are appearing, Recent reports suggest that some U. S.-based electronics firms have turned to licensing and joint ventures to help fend off Japanese competition. By licensing their technologies in South Korea, they hope to aid Korean firms in becoming effective competitors in the Far East, putting pressure on the Japanese in markets that the latter have regarded as their own.[18] The logic appears to be as follows. Japanese manufacturers have been able to achieve economies of scale in controlled Far Eastern markets, gaining advantages in production costs that help them move into the United States (and elsewhere), Korean competition, created in part through help from American firms, would reduce this source of advantage by attacking the Japanese in their traditional markets.

Strengthening potential new competitors in the Orient might seem a short-sighted approach to an immediate problem, given that the Koreans themselves are already becoming formidable competitors in some U.S. markets, as well as third countries historically served by American firms. Obviously, U.S. managements know the strategy could backfire. Evidently, they feel it is better to face two or more independent competitors than a single set of national firms acting in what many American executives believe to be concerted fashion. As pointed out above, Japanese companies have themselves been reluctant to license technologies in Korea that might threaten their own international market positions—evidence that the Japanese will take this U.S. strategy seriously.

[18]On joint ventures between Korean and American firms, see S. Chira, "U.S.-Korea Ventures Strive for Compatibility," *New York Times*, Mar. 28, 1986, p. D1; also, J.R. Schiffman and M. Shao, "South Korea and Taiwan: Two Strategies, " *Wall Street Journal*, May 1,1986, p. 36. In the semiconductor industry, more than a dozen agreements were signed during 1985 and 1986 between U.S. companies and Korean firms such as the Lucky-Goldstar Group, Hyundai, and Samsung. The three Korean manufacturers have reportedly invested nearly a billion dollars in building their semiconductor capability.

The primary point, then, is that licensing has become–not only a means of exploiting technical advantages—but a tool for developing counter-strategies against international competitors. American managers are coming to realize that gaging foreign market possibilities simply in terms of cash flows, the conventional measure of opportunity, is no longer sufficient. Entering some markets, even in modest fashion, may force competitors to alter their own strategic approaches in ways that can benefit the U.S. position.

Joint Ventures

A number of the arrangements between U.S. and Korean electronics firms have taken the form of licensing to a joint venture in South Korea—an increasingly common pattern. Motives for joint ventures linking companies that normally compete range from market entry for one of the partners to efforts to limit exposure in an unfamiliar setting. American firms have sought joint venture partners in Japan to get help in penetrating the mazelike Japanese marketing and distribution system, or to do business with such enterprises as NTT (Nippon Telegraph and Telephone), which have traditionally purchased from a small family of Japanese suppliers.

Many joint ventures involve technical licensing by U.S. companies, perhaps as an equity contribution; the American firm Halcon International licensed its ethylene oxide technology to a Brazilian manufacturer in exchange for a ***10*** percent ownership interest (beating out Shell, which had sought its own plant but could not get approval from Brazil's Government). In other examples, AT&T has purchased a **25** percent stake in Olivetti as a means of distributing its computers in Europe, while establishing a **50:50** joint venture with the Dutch firm Philips in order to enter European telecommunications equipment markets; licensing of AT&T technology is part of both agreements.

Escalating costs have also pushed firms to cooperate. International Aero Engines, which links three European and three Japanese companies with the American firm Pratt & Whitney, is undertaking a billion-dollar development effort that would be highly risky, if not impossible, for the participants individually. R&D costs likewise were a major reason for the formation of the Texas-based consortium Microelectronics and Computer Technology Corp. (MCC). As this example and Japan's fifth-generation computer project (ch. 5) both suggest, R&D joint ventures tend to be more common within nations, but they are becoming familiar internationally as well.[19] In a typical arrangement, two or more firms from different countries combine in a new company, jointly owned, to develop technologies that can be shared through cross-licensing between the joint venture and each partner. Usually, the technical agenda is tightly focused, serving to bring to bear the individual strengths of the partners on problems of common interest. Thus, Sony in Japan and Advanced Micro Devices (AMD) in the United States are cooperating on very large-scale integrated circuits. AMD expects to increase its sales to consumer products manufacturers, Sony to benefit from AMD's experience in chips for computer systems.[20]

The success of such combinations depends on each partner meeting its own objectives (which may involve matters such as taxes, financing, and risk, in addition to technology).

[19] Also see the discussions of European programs like ESPRIT and Alvey in ch. 9.

A recent survey of cooperative agreements and joint ventures covering nearly a thousand companies operating in Europe found that more than half were intended to transfer or share technology—E. Ricotta, "Joint Ventures and Inter-Company Agreements in High-Technology Sectors, " mimeo, Dec. 13, 1985, Most of the agreements had been negotiated between European and non-European (typically American) firms, with the electronics industry accounting for many more than any other sector, 44 percent of the total, Slightly more than one-third were restricted to marketing/distribution, slightly fewer involved production.

[20] Each company will have the right to market the other's products under its own name. See L.M. Fisher, "Micro Pact With Sony Is Planned," New *York Times,* Feb. 13, 1986, p. D1.

OTA'S interviews offer insights into the pros and cons of joint ventures. As one corporate manager put it, "The difference between licensing and joint ventures is that in licensing you sell your product, while in joint ventures there is joint control, joint management, and joint risk. There are more revenues with joint ventures, but you need more cash up front. ' Another noted that "Joint ventures require tremendous on-going care and nurture. It's like a marriage; if interests begin to diverge, the venture may flounder. " Also see L.H. Young, "The Corporate Links Abroad," New *York Times,* Aug. 6, 1986, p. D2.

If one partner benefits disproportionately—as some observers see happening in joint ventures linking U.S. and Japanese companies—the combination will not last long.[21] In OTA's interviews, managers in smaller American companies, faced with difficulty in keeping up with new technologies, expressed more interest in such undertakings. Despite such examples as International Aero Engines and MCC, larger enterprises with long-established R&D operations tend to be more skeptical, taking the view that quite special conditions are needed to make joint ventures attractive.

Acquisition of Foreign Technologies

As the balance of payments figures on licensing presented earlier in this chapter demonstrate, U.S. companies have sought foreign R&D results far less often than they have transferred their own technologies abroad. With comfortable leads, where was the need? Although exceptions have always existed, as when U.S. firms licensed the Pilkington process for plate glass, or when DuPont began making polyester under license from British Calico Printers, the rule was to ignore technical knowledge developed abroad. Today, the rules have changed—although some American firms seem not as yet to have realized it. In industry after industry, American technology is little if any better than that of foreign manufacturers. In a surprising variety of cases, foreign firms have moved ahead—automobile technologies ranging from combustion system designs to active suspension control, consumer electronics, some kinds of steel-making and machine tool technologies, As a result, American managers are beginning to view acquisitions of foreign technology as a necessary part of their own planning, a complement to internal R&D. When General Electric decided to enter the industrial robot market, the company screened and evaluated technologies globally, eventually selecting know-how from Japan, West Germany, and Italy.

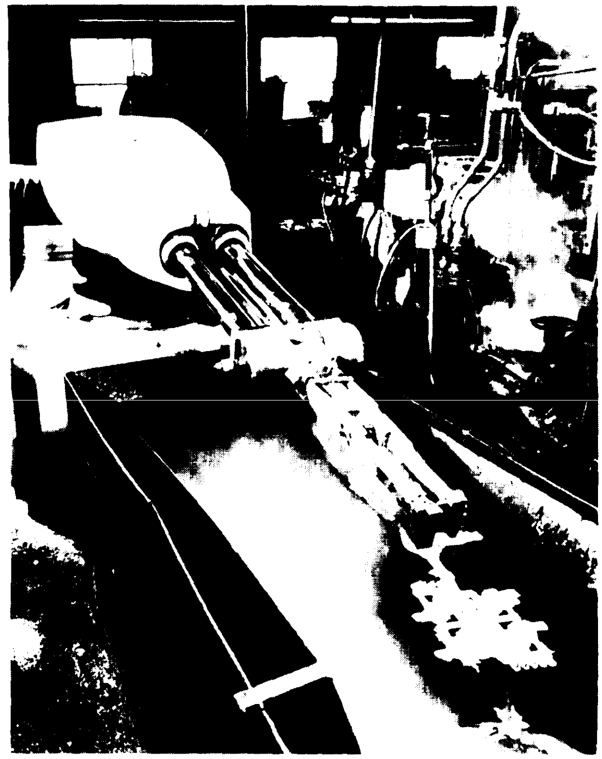


Photo credit: Unimation

Industrial robot

Greater need to specialize in their development efforts also drives U.S. companies to seek know-how overseas. With R&D costs rising rapidly in some fields, even companies as dominant in their industries as IBM cannot aspire to excel in all technologies related to their products. As a result, more and more companies are seeking to identify the technologies most important in their primary lines of business—their core technologies—and concentrate their resources on them. Other technologies they shop for, and, increasingly, shop internationally. At the same time, many U.S. firms that could plainly improve their competitive ability through the acquisition of foreign technologies fail to recognize their needs, the opportunities, or both.

[21]See R. B. Reich and E.D. Mankin, "Joint Ventures With Japan Give Away Our Future," *Harvard Business Review*, March-April 1986, p. 78, who seem to think that, somehow, American companies can never win in business arrangements with the Japanese. For a more balanced view, see D.C. Mowery, *Alliance Politics and Economics: Multinational Joint Ventures in Commercial Aircraft* (Cambridge, MA: Ballinger, 1987),

On some of the broader, strategic aspects of joint ventures, see K.J. Hladik, *International Joint Ventures* (Lexington, MA: Lexington Books, 1985), pp. 27-28. Hladik relates that Egypt barred Coca-Cola from bottling and selling its products from 1967 to 1977 because the company had franchised a plant in Israel. The ban was rescinded after Coca-Cola entered a joint venture with Egypt's Government to grow citrus in the desert.

POLICY ISSUES

The earlier sections of this chapter raise three rather different sets of policy issues, The first consists of U.S. Government policies that affect licensing itself—questions such as intellectual property protection, export controls, and antitrust restrictions on licensing contracts. The second set of issues, far broader, and dealt with below in greater detail, concerns the Nation's technology base, and the policies that contribute to strengthening it (e.g., through R&D) and to utilizing it (e. g., by facilitating diffusion of technologies within the U.S. economy). Third, foreign governments have become much more sophisticated in their use of policy tools to encourage technology transfers from U. S.-based firms, raising questions of the appropriate response by the U.S. Government. Specific policy options, once again, have been left for chapter 10.

The Policy Environment for Licensing

Legal rights granted by governments in the form of patents, copyrights, and trade secrets underlie international trade in technology, with patent and trademark licensing particularly important in industries including chemicals, pharmaceuticals, and food products.[22] Because stronger protection for intellectual property has become a U.S. negotiating objective in the Uruguay Round of trade talks, it is discussed in that context in chapters 9 and 10.

Export controls have been a contentious matter for years, with Congress amending the Export Administration Act of 1979 in 1985. The Act authorizes restrictions on exports, including international transfers of technical information, for reasons of national security. The major objective of these controls is to prevent, or at least slow, flows of technology having potential military applications to the Soviet Union and its Eastern European satellites, A history of policy controversy within the Federal Government has meant continuing uncertainty. Delays in the processing of applications covering proposed licensing agreements have sometimes been lengthy. Managers interviewed by OTA claim that foreign companies sometimes avoid U.S. sources of technology because of the possibility of delays and constraints on their use of licensed know-how. H.R. 3, the omnibus trade bill passed by the House of Representatives in April 1987, incorporates further amends to the Export Administration Act,

Until the late 1970s, the Antitrust Division of the Department of Justice maintained a published list of nine licensing practices considered per se violations of the law. American companies could not insist on contract provisions barring foreign licensees from using transferred technology to sell in the United States. Nor could they control their licensee's prices. While other per se violations pertained only to domestic licensing, business executives and their lawyers could never be sure that the Justice Department would not extend these constraints to the international sphere. As a consequence, most American companies steered clear of such provisions in their contracts with foreign firms. In the view of most managers, the list of per se violations discouraged licensing by reducing the firm's ability to control its proprietary technology.

Beginning during the Carter Administration, but especially since 1980, the Justice Department has modified its view of antitrust enforcement, with officials articulating considerably more tolerant standards.[23] In the new view, al-

[22] *Licensing in International Strategy: A Guide for planning and Negotiations,* op. cit., p. 125,

Given the ways in which technology has been evolving, piecemeal revisions to legal protections for intellectual property seem increasingly inadequate, as discussed in more detail in ch. 9. Also see *intellectual Property Rights in an Age of Electronics and Information* (Washington, DC: Office of Technology Assessment, April 1986],

[23] For instance, "Remarks of Charles F. Rule, Deputy Assistant Attorney General, Antitrust Division, U. S. Department of Justice, 'The Antitrust Implications of International Licensing: After the Nine No-Nos,' Before the World Trade Association and the Cincinnati Patent Law Association, ' (let. 21, 1986.

On U.S. antitrust law in general, see *U.S. Industrial Competitiveness: A Comparison of Steel, Electronics. and Automobiles* (Washington, DC: Office of Technology Assessment, July 1981), pp. 184-185; and *International Competitiveness in Electronics,* op. cit., pp. 390 and 465, The National Cooperative Research lowing a licenser to place limitations on a licensee's freedom of action, domestic or international, can lead to more competitive markets, greater efficiency, and higher levels of R&D spending. Restrictive provisions in licensing agreements, therefore, should not be assumed anticompetitive per se, but rather be evaluated on a case-by-case basis. Because of this well-publicized shift in antitrust policy, managers express far less concern about inserting restrictive clauses in licensing agreements than during the 1970s. Corporate legal departments, nevertheless, continue to urge conservatism—their job as they see it—given that the more relaxed enforcement attitudes have not yet been supported by clear case precedents.

The actual impacts of the new policy stance, as they relate to technology development, remain to be seen. While abandoning per se violations may stimulate technology development by increasing potential rewards to innovators, such conjectures remain, for the moment, in the realm of theory. Caution seems in order, if only because of examples of past policy shifts with smaller than predicted impacts (R&D tax credits, ch. 10). Beyond this, some of the lessons of the past seem to have been overlooked. Strict enforcement of antitrust laws in earlier years clearly led to enhanced technology diffusion, and thus greater competition, in some industries. The obvious case is the mandatory licensing of patents flowing from Bell Laboratories under the AT&T consent decree of 1956, which helped stimulate the enormously dynamic merchant semiconductor industry. This industry would look considerably different had AT&T been allowed to hold its technology then as closely as it does today. Similarly, the independent computer software industry in the United States—which developed much faster than in other countries (ch. 5)—owes much of its rapid start down the learning curve to IBM's unbundling of software sales from hardware. IBM took this action in 1969 only under threat of antitrust proceedings. Given such examples, it seems reasonable to ask whether U.S. high-technology industries would exist in anything like their present form if today's antitrust climate had existed during the 1950s and 1960s.

R&D and Technology Development

Earlier sections of this chapter stressed that competitiveness in supplying technology, or, more broadly, in trading technically based goods and services, depends on R&D directed at commercial technologies—and not only R&D, but the diffusion of results. Both development and diffusion depend to considerable extent on government policies.

In the United States, the Federal role has been twofold. Government agencies have provided most of the financial support for R&D related to national defense and space exploration. Sometimes this funding has contributed to strong, internationally competitive industries: e.g., digital computers, commercial aircraft. Second, the Federal Government has funded most research in basic science. Here the justification has been essentially economic: without government assistance, the private sector would underinvest from a societal point of view. Government funding enlarges the pool of basic scientific knowledge, which then becomes available to all potential users. The fruits of this policy have been especially evident in industries that utilize research results flowing from health-related R&D.

As a rule, many years separate the generation of new scientific knowledge from commercial application. Furthermore, much defense-related R&D is not only narrowly specialized, but classified, and not readily available to companies outside the community of aerospace firms and military contractors. This alone delays commercial applications, even though the proportion of military funds going to applied R&D, as opposed to basic research, far exceeds that in most other Federal agencies. (Basic research, almost by definition, tends to be well removed from possible incorporation in commercial products.)

(continued from previous page)
Act of 1984, which explicitly permits certain forms of joint R&D, has been the only recent change in the statutes to be enacted by Congress. During 1986, the Justice Department proposed a series of five bills, including amendments to the Clayton and Sherman acts, that would relax existing law substantially.

The Federal Government has seldom funded technology development closely tied to commercial products and processes. Despite exceptions such as energy R&D during the 1970s, commercial efforts have normally been left to private firms. In part, this choice reflects a belief that government should avoid competition with the private sector. In addition, many observers believe that government involvement would inevitably lead to distortions in the market, hurting some companies while helping others. Thus, U.S. technology policy has operated on the principle that, since private firms derive the primary benefit from commercial technology development, they should foot the bills.

The gray areas—energy-related research, some civil aviation technologies, a good deal of health-related R&D —typically fall in what has been called generic or pre-competitive technology development: R&D necessary for building a knowledge base to support all companies in an industry. In this sense, the argument for supporting pre-competitive technologies is much like that for basic research. Benefits that might be elusive and indirect for an individual firm may nonetheless yield large social benefits.

The Reagan Administration's policy has been to withdraw support from the gray areas, and count on the private sector to support them. The government has, at the same time, stepped up defense R&D, which in 1987 will, together with space, account for nearly 80 percent of Federal R&D dollars. Federal spending for basic research in the physical sciences has also been growing relative to other parts of the government R&D budget, with non-defense applied research shrinking dramatically. Finally, the Administration has increased funding for research in engineering, primarily through the National Science Foundation (NSF), and in part because of concern over lagging U.S. competitiveness (ch. 10).

Some defense-related technologies have substantial commercial spillovers, For example, the Department of Defense spends a good deal of money on computer research and on very large-scale integrated circuits, But in other countries, government support for similar research might center more directly on commercial product development (see ch. 9). If past history is a guide, significant commercial applications of the results of defense-related research will be the exception, not the rule.[24] Put differently, if commercial technology development is the goal, military R&D is not an efficient means to reach it.

Other governments have often designed special programs aimed at improving national capabilities in advanced technologies of commercial significance. Prominent examples include Japan's fifth-generation computer project, and related software development efforts (ch. 5). The fact is that most other industrialized nations devote a larger fraction of government R&D spending to projects directly related to industrial technologies, In biotechnology, for instance, while the United States has the largest and most extensive basic research effort in the world, the Japanese Government leads in its commitment to generic and applied research. [25]

Diffusion of R&D results raises a similar set of issues, Government-sponsored programs in other countries frequently combine support for technology development with efforts to transfer technology to industry, seeking to speed adoption and cut learning costs. Moreover, as noted earlier in this chapter, given rough technological parity in many fields, American companies now have a good deal to learn from overseas. But, in part because the United States was ahead for so long, mechanisms for learning from foreign experience remain poorly developed, Chapter 10 discusses policy options for strengthening these mechanisms.

[24]" Development and Diffusion of Commercial Technologies: Should the Federal Government Redefine Its Role-?' staff memorandum, Office of Technology Assessment, Washington, DC, March 1984.

Compared with efforts abroad, the impacts of' greater Federal funding for NSF's engineering research will be small. The sums involved are simply not great enough to make much difference, given the trends examined earlier in the chapter; NSF's budget for engineering during fiscal year 1987 comes to $163 million out of a total NSF research budget of $1.62 billion.

[25]*Commercial Biotechnology: An International Analysis* (Washington, DC: Office of Technology Assessment, January 1984), pp. 505-510.

Foreign Government Policies

Less developed and newly industrializing countries have been much more likely to restrict foreign direct investment than the advanced nations, Broadly speaking, the LDCs and NICs have sought to control investment in pursuit of three interrelated goals:

1. *Economic* Growth.—Many governments regulate inward investment, seeking to steer foreign capital to sectors considered desirable for fostering economic growth and development.
2. *Technology Transfer.-By* permitting FDI only if accompanied by transfers of technology, governments have sought to build their infrastructures and develop a skilled labor force.
3. *Autonomy .—Closely* related to the first two objectives, many developing countries wish to limit production and market share by foreign-based MNCs in key economic sectors, reserving these for their own companies.

From the U.S. perspective, the policy issue that arises is straightforward. Foreign government policies can distort corporate decisions concerning the use of proprietary technologies. The consequences may be harmful to U.S. interests, Most obviously, in the absence of foreign government incentives and/or restrictions, American companies might use their proprietary technologies to produce at home and export. Of course, such considerations cut two ways. The U.S. Government has imposed restrictions on imports, or threatened to, with increasing frequency since the middle 1970s, As a result, foreign firms in industries ranging from consumer electronics to automobiles have opened manufacturing plants in the United States.

In fact, many governments have a schizophrenic attitude toward MNC involvement in their economies. On the one hand, they may encourage inward investment through incentives including low-interest loans, tax rebates, training grants, and tariff and foreign exchange preferences, Typically, governments offer such incentives to companies they wish to attract—i.e., those whose presence is consistent with policy makers' views on development needs. But selective investment incentives may conflict with objectives related to technology transfer and autonomy. An MNC that accepts the incentives will want to conduct its business much as it does elsewhere, integrating its local operations into the global enterprise. For example, the MNC might wish to license a subsidiary, although the government prefers that technology be transferred to locally owned firms. If the government insists on a joint venture as a condition of entry, perhaps with the multinational taking a minority position, the MNC's choice can be a painful one: share its proprietary technology with a local partner, and risk losing control, or forgo the prospect of present and future business in that country. Needless to say, different companies make different decisions in such circumstances, depending to some extent on the strengths of their bargaining positions.

It is also true that many foreign joint ventures simply reflect strategic needs, with little or no influence from foreign government policies. As pointed out earlier, joint ventures can reduce risks in unfamiliar markets—limiting financial exposure while drawing on the experience of local firms familiar with marketing and distribution practices. Although direct investment and joint venture decisions may reflect foreign government policies, they may at the same time reflect the firm's desire to pursue an integrated international strategy. Indeed, most American managers view government efforts to manipulate markets as just another exogenous element to be fitted into the strategic puzzle.

Other foreign government policies affect licensing more directly. Taxation of corporate income but not of royalty flows encourages licensing of affiliates, with royalties becoming one method for transferring funds within the MNC. For this reason, host governments may tax international transfers involving royalty payments, In addition, with foreign exchange a scarce resource in most developing economies, governments often seek to control international payments directly. As with many such regulations, governments tend to use rules of thumb. These typically constrain allowable royalties to a narrow range, Licensers might find the permissible royalties adequate, even generous, for some technologies, but quite inadequate for others (when set against the risks of losing control of proprietary know-how). A country that restricts royalties too tightly, thus cutting itself off from some technologies, may complain about the monopolistic practices of multinationals, even though the royalties in dispute may the norm in other parts of the world. The result? Lower levels of licensing revenue for the U.S. company, coupled with less technology of potential use to the developing nation.

Finally, governments sometimes attach direct conditions to licensing agreements—attempting, for instance, to accelerate technology transfers through unusually short licensing periods. Both Mexico and Brazil limit trade secret protection to 5 years. In the view of most corporate managers, this is far too little time to permit adequate earnings from proprietary knowledge. Although renewals are possible, there are no guarantees. Such conditions, always accompanied by trade barriers, have caused many firms simply to stay away. At the same time, relatively large countries like Mexico and Brazil, with attractive potential markets, have considerable leverage. They have often been successful in playing foreign companies off against one another. In other cases, however, developing countries have lost the benefits of technology transfer by attaching conditions that foreign firms have been unwilling to accept. Brazil, for example, has established such stringent conditions relating to small computers that no company with up-to-date products has agreed to transfer technology.

CONCLUDING REMARKS

Technical knowledge spreads internationally through many channels other than licensing—when foreigners study engineering and science in American universities, later to return home, they take technology with them. Competitors engage in reverse-engineering, pervasive in the earlier years of the semiconductor industry. Foreign subsidiaries are staffed largely by local people; when they leave for other jobs, their knowledge goes along. In R&D alone, the overseas manufacturing affiliates of U.S. firms employed some 70,000 foreign nationals in 1982.[26]

With diffusion of technology inevitable, firms try to capitalize on it rapidly, before its value declines too much. In different circumstances, this may imply exporting goods (or services], direct investment, or licensing, Decisions on which technologies to license, and where, depenal on a firm's strategic view. The company will look at the size of potential markets, at available close substitutes, at the risks of losing control over proprietary knowledge. An American firm may prefer to export but find dollar exchange rates discouraging. Foreign government policies may close off investment. If it wishes to license, it may be pushed toward joint ventures with local companies.

Among the risks that a firm must evaluate, perhaps the greatest is that it will lose future sales to its licensees. No matter how tightly the licensing agreement is written, defining precisely where and how the technology can be used, leakage and counterfeiting become more probable once the technology is in use in someone else's plant. Moreover, enforcement of the terms of the agreement can be difficult in a foreign country. All these factors make it difficult to set fees for technology licenses.

Given the risks and uncertainties, arms-length agreements—though large in number—remain small in value compared to licensing between affiliates. But it is also true that intra-corporate licensing remains largely hidden from the view of the U.S. Government, primarily because

[26] *U.S Direct In vestment Abroad: 1982* Benchmark *Survey Data* [Washington, DC: Department of Commerce, December 1985), p. 243. Total employment in overseas manufacturing affiliates of U.S. firms came to 3,4 million. Of 76,000 R&D employees, no more than 6,500 were U.S. citizens.

charges between divisions of the same company will seldom adequately reflect the value of the licensed technology. For this and other reasons, statistics on technology trade give little real sense of the impacts on international competition (or on domestic employment).

For the United States, Europe remains the major trading partner in technology. European firms represent the largest source of licensing receipts and the largest recipient of U.S. payments, although inward transfers from Japan have been increasing more rapidly; technology imports from Europe grew by 19 percent between 1983 and 1985, but imports from Japan jumped by 29 percent.

Over the years, U.S.-based MNCs have begun transferring more advanced technologies; with foreign firms catching up, only the latest knowledge has value to them. As this and many other observations suggest, American firms do not have as strong a technological position, relative to the rest of the world, as they once enjoyed. By many indicators, U.S. priorities for non-military technology development have fallen below those of other countries, notably Japan. Although a weakened balance of payments position in licensing is among the less serious consequences of diminished comparative advantage in technology, it does have its effects. Moreover, the LDCs and NICs are demanding the most recent know-how, which makes it more difficult to hold on to the advantages that remain.

In interviews, many managers of U.S.-based firms stated that overseas exploitation of technological advantages has become more difficult in both developed and developing countries. While enterprising American firms have found ways of dealing with foreign government restrictions, more and more of the intracorporate avenues are being closed to them; the consequences include increases in joint ventures and arms-length licensing agreements. Given these circumstances, American firms increasingly employ licensing as one element in quite complex strategies. At least for larger multinationals, these are likely to be global in scope. Corporate managements spend a good deal of time positioning their firms for ongoing international competition. For firms whose advantages lie in technical knowledge, licensing becomes an integral part of forward planning.

What of the claim that, by underpricing their technology, American firms have helped foreign competitors catch up? In fact, matters are seldom so simple, as the following example illustrates. Texas Instruments, as is well known, used its patent position as a wedge to enter Japan's semiconductor market.[27] What is less well known is that TI's management believes strongly in onsite manufacturing as a necessity for competing in high technology. TI felt that, to sell in Japan, the company had to manufacture there. In 1968, it traded licenses—covering technology TI had already made available to its U.S. rivals, but no trade secrets—for permission to establish a 50:50 joint venture with Sony. TI insisted on the right to buy out its partner after 5 years, and thereafter operate a wholly owned subsidiary—a provision which it expected to exercise from the beginning, and did. Today, TI claims that it is gradually coming to be treated as a Japanese business. The company maintains cross-licensing agreements with all the major Japanese semiconductor manufacturers, and expects—like IBM before it—to enter into a cross-licensing agreement with MITI (important because many patents resulting from joint government-industry R&D revert to the Ministry). Did TI underprice its technology? While Texas Instruments evidently does not think so, the firm's U.S. competitors—which did not have strong enough technological positions to force their way into the Japanese market in earlier years—might well differ.

In any case, if American companies licensed technology to potential rivals in Japan under terms that—with hindsight—seem too liberal, most of these mistakes were made a decade or more in the past, before Japan's rising competi-

[27] *International Competitiveness in Electronics*, op. cit., pp. 140 and 193-194.

tiveness was obvious to all. Few American managers would any longer underestimate their Japanese rivals. At this point, the pressing need is for better developed mechanisms through which U.S. firms, in many industries, can learn from foreign technical developments. A more rapid increase in inward licensing, implying broader recognition by U.S. industry of the need for two-way flows, would be a favorable sign for future U.S. competitiveness, But most important of all, U.S. policymakers need to attend to a pressing series of problems that affect the technology base for all of American industry. Many of the needs have been well-documented and widely acknowledged—e. g., lack of laboratory equipment in the Nation's universities. The problems have been identified, but they have not been solved.