Technology Transfer From Foreign Direct Investment in the United States: Report of a Seminar Series (1976)

Pages
80

Size
8.5 x 10

ISBN
0309335736

Office of the Foreign Secretary; National Academy of Engineering; Assembly of Engineering; National Research Council

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Report of a Seminar Series
Conducted by
Office of the Foreign Secretary, National Academy of Engineering
and
Assembly of Engineering, National Research Council

National Academy of Sciences
Washington, D.C., 1976

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This project was supported by the U.S. Department of Commerce and the National Science Foundation. The work was completed under Contract No. NSF C-310, Task Order 333, between the National Science Foundation and the National Academy of Sciences.

Available from
Office of the Foreign Secretary
National Academy of Engineering
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

Order from
National Technical
Information Service,
Springfield, Va.
22161
Order No. PB 263-012

TECHNOLOGY TRANSFER FROM FOREIGN DIRECT INVESTMENT IN THE UNITED STATES

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Technology Transfer From Foreign Direct Investment in the United States

INTRODUCTION

This report summarizes the proceedings of four one-day seminars at which foreign direct investment in the United States was examined to determine how it affects the transfer of technology into and out of the country. The seminars were conducted in New York City, February 2-5, 1976, by the Office of the Foreign Secretary of the National Academy of Engineering, working jointly with the Assembly of Engineering of the National Research Council. These organizations accepted the responsibility of examining the issue at the request of the National Science Foundation and the Department of Commerce.

In exploring the nature, scope, and magnitude of technology transfers resulting from foreign direct investment, the seminars specifically sought to ascertain what is known about:

1. The overall relationship between such investment and the manner in which technology flows into and out of the United States.

2. The balance between these inward and outward flows.

3. The resulting benefits and costs to the United States.

After World War II the United States spent billions of dollars to reconstruct the battered economies of friend and foe alike in Western Europe and Asia to help construct a prosperous and stable world. An important part of this effort was the transfer of technology. Its success has contributed to some of the challenges faced by the U.S. economy--most notably, competition from abroad and investment in American companies by foreign interests. Both raise important questions about technology transfer.

The need for information about technology transfer from foreign direct investment arose out of a national concern with the acceleration of foreign holdings in the United States during the past several years. Department of Commerce data show that in 1973 and 1974 there were increases of 20 percent over each preceding year, bringing the estimated value of foreign

investment to $21.7 billion at the end of 1974.[1] This was 200 percent greater than in 1960. Although six countries of Western Europe, together with Canada and Japan, accounted for 86 percent of the 1974 total, the accumulation of funds by the members of the Organization of Petroleum Exporting Countries, together with the sharp increases in Japanese investment during 1973 and 1974, intensified this concern and contributed to the enactment of the Foreign Investment Study Act of 1974 (Public Law 93-479).

The overall purpose of this act is to give the makers of public policy a more complete and precise understanding of the effects of foreign investment activities on U.S. national interests. While some foreign investment projects have permitted the United States to exploit technology that was originally developed abroad, there are also cases in which foreign firms have acquired American companies and, thereby, gained access to technology that could subsequently be transferred abroad to units of the foreign firm. However, the available information provides neither a broad nor a detailed picture of what is occurring.

To correct this, the Foreign Investment Study Act required the Secretaries of Commerce and the Treasury to conduct studies and report to the Congress on both direct and portfolio foreign investments in the United States. As a result, more than eighteen different studies have been initiated into specific aspects of foreign direct investment in the United States. Most of the studies are still under way.

Although technology transfer is an element in several of the studies, this subject was considered sufficiently important to warrant a special examination by knowledgeable representatives from industry, government, and academia who would review the relevant experiences and perceived trends in a few key sectors of technology-intensive industry.

To this end, the National Academy of Engineering and the National Research Council were asked to conduct a series of seminars on technology transfer from foreign direct investment.

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1. Foreign Direct Investment in the United States, Interim Report to Congress: Vol. 1, U.S. Department of Commerce, October 1975.

Seminar Guidelines

In planning the seminar series several guidelines were established:

1. Foreign companies may invest in the United States for reasons having nothing to do with technology transfer. Thus, a company might invest strictly to obtain a cash return on its investment or because it believes that manufacturing and, perhaps, even conducting R&D will help it gain knowledge of the U.S. market. What is more, technology transfer can be brought about in many ways other than direct investment--e.g., by licensing, by technical exchange agreements, by diligently attending technical meetings and reading technical literature, by analyzing another company's product, and by hiring people away from another company. The seminars were planned to determine the extent of technology transfer associated with direct investment and to provide perspective on the importance of this transfer as a factor in foreign investment.

2. Only significant transfers of technology that have occurred since 1960 were considered. In addition, technology of military significance was excluded.

3. A broad definition of technology was adopted. Specifically the term was understood to include not only the results of applied research and the means of production but innovative management and marketing techniques as well. However, it was further decided that the identification and evaluation of marketing and management innovations would be a secondary, or even incidental, result of the series. Consequently, in selecting the participants, emphasis was placed upon inviting people familiar with process and product technology.

4. Although direct investment is defined by the Department of Commerce simply as an equity interest of 10 percent or more, the term was used in the seminars to imply some degree of managerial involvement as well. Considered this way, equity investment differs from portfolio investment, which involves no managerial participation.

Technology Inflows and Outflows

The basic question explored at the seminars was the shift in the technology position of the United States with respect to

the rest of the world, as a result of technology transfers, without regard for the associated financial flows and other consequences. Thus, it was assumed that a technology "inflow" would represent a positive effect and a technology "outflow" a negative effect. A few hypothetical examples will illustrate some of the situations discussed at the seminars.

As a first example, if a German chemical company builds a new plant in South Carolina to produce a synthetic fiber developed in its laboratories in Germany, this represents an inflow and a positive contribution. The reason, of course, is that it adds to America's "technology stock." Technology transfer is not the only effect of the investment, of course. It also could strengthen America's international economic position by replacing imports with domestic production; however, it could also displace a domestic product in the U.S. market. Thus the financial flows may differ from the technology flows.

On the other hand, consider a Japanese company that lags behind its competitors technologically in producing desktop calculators and electronic parts for its domestic market. If this firm were to invest in a U.S. company in order to tap American manufacturing and research technology, this would represent an outflow of technology from the United States.

It is clear that technology transfer is not a "zero sum" game--that is, a technology inflow increases the U.S. technology but does not diminish the supply elsewhere, and an outflow increases it elsewhere but does not diminish the U.S. stock.

While it would have been helpful if most cases had fit neatly into either the category of inflow or the category of outflow, the seminar participants recognized that some cases could involve both an inflow and an outflow and thus be difficult to evaluate in terms of net effect. Consider as another case the U.S. subsidiary of a Swiss company that maintains both production and R&D facilities in Switzerland and in the United States and develops a new pharmaceutical product as a result of R&D in both countries. It then proceeds to manufacture for the domestic market as well as for export. At this stage there is an inflow of technology and an addition to the technology stock in the United States. Later on, however, if the Swiss company were to transfer the technology partially developed in the United States to some of its foreign subsidiaries and begin production at these subsidiaries for their local markets, a technology outflow would have taken

place. In sum, the stock of U.S. technology has increased, despite the outflow. The stock of technology outside the United States has also increased.

One way of handling such cases of technology outflows from U.S. subsidiaries of foreign-controlled companies is simply to identify and describe them without attempting to determine whether or not a net effect has occurred. While there are justifiable reasons for doing this only, the seminar participants, nevertheless, attempted in a number of cases to indicate the net effect.

Foreign direct investment can bear upon the technology stock through a financial flow, quite apart from any associated technology flow. Consider a Japanese company that buys into a small American computer firm. The risk capital contribution of the Japanese direct investment helps augment the U.S. technology stock by allowing the U.S. firm to develop and commercialize new technology in the computer field. At the same time, it allows the Japanese company to secure access to technology it could use in its non-U.S. operations.

The Industries

As measured by the "investment position" of foreign investors in the United States, manufacturing appears to account for about one-third of the total foreign direct investment, with petroleum refining and extraction, finance and insurance, and wholesale trade representing three other large sectors.

Because the purpose of the seminars was to examine technology transfer, however, the emphasis was put on manufacturing and, within it, four high-technology sectors where there is reason to believe significant technology flows may have occurred. Although technology transfer takes place in a number of industries, the examinations conducted by the seminar participants were selected on the basis of the best available information from the Department of Commerce. These sectors dealt with

- Pharmaceuticals,
- Electronics, computers, and scientific instruments,
- Non-electrical machinery, and
- Petrochemicals and their derivatives.

The Approach

The acquisition of hard information on technology transfer from foreign direct investment is not easy. Most companies consider their technology to be proprietary knowledge. Descriptions of technology and data about technology transfers may be described by them in, at most, rather general terms. The most authoritative sources of such information are those people in the industry whose broad responsibilities require them to follow and assess developments in the industry, including particularly those involving technology. These individuals may provide the best available information about their own companies and command the most knowledge (among outsiders) for an evaluation of technology transfers for other companies in their industry.

For these reasons, and in order to obtain information in the shortest possible time, the approach chosen was to convene a a series of four, one-day seminars, each attended by a group of broadly informed people within an industrial sector. Most of the seminar participants were associated with companies in the industry, and they all possessed broad technological responsibility and experience. In particular, they were chosen to provide viewpoints that encompassed technology flows on an international scale. This generally meant that their companies are multinationals, which, as a group, are foreign investors in other countries. In addition, the discussions included a small number of non-industrial experts whose background qualified them to comment on the subjects of the seminars.

A rapporteur for each session was given responsibility for writing the proceedings of the seminar, working from his own notes and the recorded transcript of the proceedings. Each report was subject to later correction and clarification by all participants in the seminar.

The Methodology

The seminars were concerned only with evaluation of technology flows resulting from foreign direct investment. Other consequences relating to such matters as balance of trade, employment, social values resulting from innovation (of a new therapeutic drug, say), and foreign policy considerations were not dealt with. Some of these are the subjects of other studies supported by the Department of Commerce.

To focus the discussion, the participants were given the following suggested topic outline:

I. Concentrating on the selected industries in which foreign direct investment is important, what do we know about

   A. Significant recent (since 1960) transfers of technology into or out of the United States as a corollary of direct investment by foreign firms and the effects of such transfers on the position of U.S.-owned firms operating in the same industrial sectors?

   B. The acquisition of technology as a motivating force for direct investment in the United States?

   C. The role of direct investment as a vehicle for the transfer of technology in preference to other forms such as licensing or importing?

   D. Perceived industry trends pertaining to the net direction and magnitude of technology flows into and out of the United States?

   E. The degree of foreign control (percentage of foreign ownership of U.S. subsidiaries) as a factor affecting the level of technology transfer?

   F. The effects of inward and outward technology flows resulting from inward direct investment on:

      1. The expansion or contraction of industrially funded R&D activities in the United States

      2. Changes in domestic industry employment

      3. Magnitude, rates, and other aspects of royalty payments

      4. Prices, new products, product quality, etc.

      5. Restrictions on exports from the United States and other marketing limitations

      6. Availability of new foreign technology from foreign parents to their U.S. subsidiaries

      7. Others

II. What do we know about the relationship, if any, of technology flows resulting from foreign direct

investment in the United States to transfers resulting from direct investments overseas by U.S. firms? [See Sections 5 (10) of P.L. 93-479]

III. Speculations on future technology flows.

In the case of wholesale trade, which includes the large investments of the Japanese trading companies and the distribution networks of the foreign automobile companies, the seminar participants were instructed to consider the introduction of new or advanced products into the U.S. market as an extension of the importing process rather than as a technology transfer related to direct investment.

A number of the participants "researched" the subject of the seminars in advance by collecting information within their own companies and by consulting other sources in the industry. Thus, their comments at the seminars went well beyond the casual level of impressions, and in fact represented considerable preparation and careful thought.

The accounts of the four seminars present only those observations and views that were widely accepted by the group. While these represent the views of well-informed people, it cannot be guaranteed that the proceedings are entirely accurate or complete in the sense that all significant cases of technology transfer in the industry sector were discussed. Nevertheless, a reasonable approach to this was achieved.

If the seminar accounts fall short, it is because of the essentially proprietary aspects of the subject under consideration and because a limited number of participants, no matter how well informed, could not totally represent a major sector of industry. The seminar participants doubted that any important cases of technology transfer in these industries were omitted. Even so, it was more difficult to measure the extent of the technology flow in particular cases, because of the proprietary nature of the information at hand. Although the participants expressed their views openly, the seminar sections were written to reflect the degree of uncertainty about the evaluation. The accounts deal mainly with the facts of technology transfer as known to people knowledgeable in the four industries. The sponsors, the Commerce Department and National Science Foundation, also requested the participants for judgments regarding future trends and national benefits in connection with technology transfer. Opinions about trends and benefits, of course, depend upon viewpoints as well as facts.

Thus, the seminars do not constitute a definitive analysis of the subject. Nevertheless, the cases described and evaluations presented during the seminars could serve as a useful guide to any further study of the complex and sensitive issue of technology transfer resulting from foreign direct investment

1. THE PHARMACEUTICAL INDUSTRY

The effects of foreign direct investment on the transfer of technology into and out of the United States depend heavily upon the characteristics of individual industries and their products and processes. Thus, in examining the transfer of pharmaceutical technology, the participants decided there were several general features of the industry that ought to be recognized before considering specific cases.

° The pharmaceutical industry is unique because its products are subject to a type and degree of public regulation, in the United States and elsewhere, that is very likely unmatched in any other industry.[2] This regulation begins with the earliest stages of the process of drug innovation and extends to the distribution of packaged products in the marketplace. Consequently, the pharmaceutical industry is not one in which companies are completely free in making technological decision. The seminar participants emphasized that manufacturers in the United States and abroad find decisions with respect to product development, international transfer, and commercial use of technology being dictated in no small measure by regulatory demands.

° Pharmaceutical technology, which has undergone deep-seated changes over the past decade, spans a remarkably broad spectrum of activities. Not only is it extremely difficult to identify a few discrete activities as the sources of pharmaceutical technology,but the participants agreed that compiling a list of therapeutic or research techniques would likewise fall far short of cataloguing the entire technology.

° Although those pharmaceutical products that are delivered to the marketplace are the visible evidence of the industry's technology, they represent no more than the end result of a broad technological capability which encompasses a highly complex innovation process. This process incorporates basic research in the life sciences, isolation of potentially useful therapeutic agents, pharmacological studies,

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2. This is true with respect to the technology of product development and production control. Public utilities, of course, are completely regulated with respect to prices.

animal trials, toxicology studies, clinical trials, development of manufacturing processes and quality control techniques, dosage formulation, and management of complex technical information systems. Moreover, it extends to marketing as well, for pharmaceutical manufacturers must transmit their R&D knowledge to physician-users. Finally, at practically every stage of this whole process, information is generated that must be assembled, analyzed, and passed on to regulatory agencies for scrutiny. In essence, the industry's core technology is the management of this total innovation process (though process in this context should not be confused with the more common notion of a single manufacturing technique).

- Neither the industry nor its technology are constrained by national boundaries. The principal advances in drug therapy have spread rapidly around the world. Indeed, the very nature of the industry's products precludes keeping important therapeutic advances "at home," wherever home might be. Recently, however, the introduction of new pharmaceutical products into the U.S. market has begun to decline, and there are concerns voiced about a new therapeutic drug lag or "drug gap." Nonetheless, technical information, particularly concerning performance in clinical practice abroad, spreads rapidly, even though the use of a new drug in U.S. medical practice may not be approved by the Food and Drug Administration (FDA) until years after its market introduction in Europe, Britain, Canada, Japan, and elsewhere. Consequently, the seminar participants emphasized that individual nations--and the world at large--stand to gain by keeping open all the channels by which product transfer can take place.

On the other hand, transfer of the innovation process occurs with much greater difficulty. Yet it is the inflow or outflow of knowledge and skills involved in this process that determines whether a country will keep pace with the technological capabilities of other nations. This raises several critical questions: What impact does foreign direct investment have upon the transfer of the many, but interconnected, technologies imbedded in the pharmaceutical innovation process? Equally important, what would be the consequences for the transfer of this core technology if the United States and other nations adopted increasingly inhospitable policies toward foreign direct investment? (The views of the seminar participants on these questions are summarized in later sections of this chapter.)

- Any assessment of the nature and direction of technology transfer in the pharmaceutical industry needs to take into account that a number of the foreign pharmaceutical companies with American operations made their initial direct investments in the United States many years ago. For instance, Hoffmann-LaRoche entered the United States around the turn of the century. CIBA set up its initial production and research facilities in the United States in 1936. Several major German pharmaceutical companies, or their corporate predecessors, established facilities in the United States prior to World War I, and these were taken over by the U.S. government during the war. Later on, this event repeated itself when the German companies returned once again, during World War II, lost their holdings. Consequently, it is only in a superficial sense that the inflow of direct investments by the German pharmaceutical companies in the last decade or so represents brand new investment. It flows then, the seminar participants stressed, that current trends in incoming direct investment have little, if any, bearing upon the technology transfer decisions of those foreign firms that have been transferring technology into and out of the United States for decades.

- In examining the origins of pharmaceutical innovations, it is common practice to credit the discovery of Product X to one country and Product Y to another. In this way, national research productivity is often compared and contrasted. However, this approach ignores the realities of research and development as now carried out in the pharmaceutical industry. Discoveries occur within laboratories located in specific countries and usually evolve into marketable therapeutic agents through the collaboration of scientists and physicians employed by the same company in several countries. In the past, most new drugs were home grown products--from inception through perfection. Today, pharmaceutical innovation has reached a point where it is an inherently international process.

Technology Gains from Foreign Direct Investment

Once the contours were depicted for considering technology transfer in the pharmaceutical industry, the seminar participants identified two principal ways in which foreign direct investment yields technology gains for the United States.

1. Foreign investment in the pharmaceutical industry almost always stimulates new R&D activity within the United States.

2. Foreign investment facilitates the transfer into the United States of innovations originating abroad.

This means, according to the participants, that the United States has better access to foreign pharmaceutical innovation under present conditions than it would if foreign drug manufacturers were prohibited from investing directly in the United States.

How does foreign investment enhance America's pharmaceutical R&D activity? The seminar participants representing drug manufacturers headquartered outside the United States repeatedly stressed one point: successful entry into the American pharmaceutical market inevitably results in the creation of full-fledged pharmaceutical companies in the United States. This, in turn, characteristically entails the organization and support of complete company-sponsored R&D laboratories. In part, this commitment to U.S.-based R&D is thrust upon incoming investors. Given the U.S. Government's comprehensive regulation of pharmaceutical innovation, clinical trials, marketing, and use, foreign investors are, for all practical purposes, compelled to conduct the full range of R&D activities in the United States. It is also clear that they make this commitment in order to join and learn from the American scientific and medical community. As it happens, foreign direct investment in the pharmaceutical industry is almost always accompanied by an increase in R&D activity within the United States.

This compelling stimulus to pharmaceutical innovation could be considered detrimental if the nation's existing stock of R&D resources is already overtaxed. After all, it could be argued, the impetus toward pharmaceutical-oriented R&D may cause a misallocation of America's clinical research, which takes in the nation's pool of scientific and technical talent as well as the capability of testing the safety and efficacy of new therapeutic drugs. However, the seminar participants decided, after a full discussion of the issue, that an excessive strain on the nation's pharmaceutical R&D resources has not taken place during the past decade--although there is increasing likelihood of this happening.

That the R&D conducted by the U.S. subsidiaries of foreign pharmaceutical companies has contributed to the availability of important new drugs in America is without question.

Notable among these contributions are the innovations developed in the U.S. laboratories of the Swiss-based firm of Hoffmann-LaRoche. Thus, Librium and Valium, two of the world's most widely prescribed tranquilizers, originated in Hoffmann-LaRoche's U.S. laboratories. Initially, they were developed with the American market in mind. In fact, according to a study by Paul de Haen, sponsored by the Pharmaceutical Manufacturers Association, and scheduled to appear in a forthcoming issue of Pharmacy Times, many of the new pharmaceutical products introduced by Hoffmann-LaRoche during the past several decades trace their origin back to the company's U.S. laboratories. As the seminar participants observed, Hoffmann-LaRoche's success stimulated several U.S. pharmaceutical companies to expand their R&D efforts. Thus, directly and indirectly, Hoffmann-LaRoche augmented America's R&D in therapeutic drugs.

Often, however, the U.S. laboratories of the foreign drug manufacturers have not discovered the basic compounds that eventually became useful products. Such discoveries mostly took place overseas. But the American-based laboratories and clinical staffs have played an important role in converting the compounds into marketable products. For example, much of the toxicological and clinical testing of Hoechst's diuretic, Lasix, was conducted in the United States in the firm's own subsidiary laboratory.

In sum, foreign direct investment in the U.S. pharmaceutical industry has added to the national level of R&D activity in practically every instance of which the seminar participants were aware, thereby bolstering the nation's overall industrial research capability. The U.S. laboratories of foreign drug manufacturers are not simply organizational vehicles for transferring foreign-generated technology into the United States, but have frequently caused major advances in pharmaceutical technology on their own.

In considering the second point about foreign direct investment--that it tends to ensure the transfer to the United States of technology to the greatest extent possible--there are a number of reasons for believing that foreign drug manufacturers would more freely pass on their innovations to their own U.S. subsidiaries than they would to, say, U.S. licensees. Indeed, as several of the seminar participants mentioned, there are a number of considerations that now make it almost essential for drug manufacturers, whether based in the United States or not, to rely upon foreign direct investment as their principal mechanism for carrying out international business and concurrent technology transfer.

First of all, as a result of increasingly stringent rules relating to the testing of drugs, the time between the initial discovery and, where permitted, patenting of a new therapeutic agent and government approval to market it has greatly increased. Though the period of a product patent extends for 17 years, in the United States as much as two-thirds of the patent life may be consumed by the process of obtaining approval to introduce the therapeutic drug. Under such circumstances, which put a premium on well-managed and efficient drug development and clinical testing programs, individual manufacturers are loathe to license their major innovations to outsiders. The time, cost, and informational penalties of dealing with non-company partners--that is, between a licensor and a licensee--are simply too high for pharmaceutical products, given today's limited patent life.

Furthermore, within any single company, drug innovation is now an international undertaking, calling for careful coordination among investigators located in several or, perhaps, many countries. Accordingly, arm's length relationships with foreign licensees, which makes coordination more difficult, are becoming increasingly incompatible with the requirements for effective drug innovation. As a result, extensive foreign direct investment is practiced by virtually all major drug manufacturers. In other words, licensing is no longer the preferred alternative by which firms can transfer technology.

Another force leading toward foreign direct investment arises from the necessity for pharmaceutical makers to monitor all markets for information relating to the safety of their drugs. Manufacturers need to have access to worldwide product information networks, and they need to be able to pool the experiences of physicians, hospitals, laboratories, and patients everywhere in order to ensure product safety. Licensees may or may not fit in with this worldwide scanning activity; so, rather than take this risk, drug manufacturers prefer to establish their own subsidiaries as data gathering points.

Apart from these important considerations, the increasing complexity of pharmaceutical innovation pushes drug manufacturers toward direct investment in foreign markets. It is simply far easier to transfer complex knowledge within organizations than between organizations. This, too, lessens the acceptability of licensing pharmaceutical products and processes.

All of these factors and forces apply to pharmaceutical companies based both in the United States and abroad. The pressures toward direct investment are generic and rooted both in the nature of current drug innovation and in the status of current government regulations at home as well as abroad. There is a fallacy in assuming that the United States could receive the same inflow of foreign pharmaceutical technology if foreign drug manufacturers were precluded from investing directly in the United States. While licensing is regarded as a mechanism for supplementing a company's R&D output, the seminar participants considered foreign direct investment preferable for the optimal development of new drug discoveries.

No matter how the transfer has been effected in the past, it is clear that the United States has benefited from an inflow of foreign-developed pharmaceutical products. Table 1 (see page 26) lists some of the many products on the American market that have been conceived or produced elsewhere. (The table does not distinguish between those products developed in the U.S. laboratories of foreign-based pharmaceutical companies and those developed in laboratories abroad because distinctions of this sort are becoming increasingly less meaningful. Some products included in the table are also sold in the United States by American licensees.)

Assessing the Balance of Technology Flows

There appear to be five complications standing in the way of coming anywhere near a precise assessment of the balance between inward and outward technology flows for the pharmaceutical industry:

1. The very broad range of activities--from frontier research in biology and chemistry to the design of scientifically informative marketing materials--makes it impossible to isolate a half dozen or so major technical advances and to consider these as the basis for judging the balance of technology flows.

2. With pharmaceutical technology embodied in organizational capabilities as well as in products, no clear-cut criteria exist for determining whether the United States gains or loses when, for instance, a foreign investor

transfers an important new therapeutic agent to the United States and simultaneously disseminates a new clinical testing technique that originated in the United States to its other foreign subsidiaries.

3. That foreign investors have operated in the United States for different lengths of time also complicates the analysis. Predictably, recent investors tend to rely rather heavily upon their parent firm's reservoirs of technology. To the extent that they do, the United States benefits from an inflow of technology. By contrast, long-standing investors, who almost always conduct substantial R&D in the United States, frequently seed their worldwide affiliates with discoveries or improvements from their American operations. This finding suggests that foreclosing new direct investments by this industry in the United States will cause a future shift from an inflow of technology to an outflow.

4. An even more fundamental complication arises from the worldwide scale on which innovation occurs today within each of the major pharmaceutical makers. The notion that a new agent is discovered, tested, and eventually turned into a commercially acceptable product--all within a single country--does not match the reality of pharmaceutial innovation. Within individual companies, the discovery phase often calls for collaboration among laboratories and investigators located in several different countries. Similarly, clinical testing almost always expands into a multi-country project. Even the later stages of drug innovation--dosage formulation, for example--often incorporate inputs from more than one country. Furthermore, since the gestation period for a major new therapeutic agent can now run to 10 years or more, the flow of technology among countries often extends over very long periods. In short, when any new drug is born these days, it is seldom native to any one country. This being the case, attaching the label inflow or outflow to pharmaceutical products, or to the antecedent discoveries that made these products possible,

obscures the fact that many of these innovations owe their birthright to open, free-flowing, world-wide R&D.

Two prominent cases where a foreign investor had bought into a previously owned U.S. drug company demonstrate the difficulty of assessing the net direction of technology flow--the acquisition of Cutter Laboratories by Bayer AG (Germany) and the acquisition of Stuart Laboratories by Imperial Chemical Industries Ltd. (Great Britain) through merger with Atlas Chemical Industries (U.S.). Cutter is initially causing an outflow of technology (principally in vaccines), but this may well shift to an inflow as Bayer begins to introduce products from its own laboratories to Cutter and as Cutter exports the results of its research to world markets. There is the prospect of the same kind of shift in flow between Stuart Laboratories and ICI, although in this case the technology appears to be principally that associated with formulation, packaging, and marketing.

Four Examples of Technology Transfer

Although it is not possible to quantify the inflows and outflows of technology, a brief review of experiences reported by the seminar participants provides a good sense of what is happening in the industry.

- The R&D activities of the U.S. subsidiary of one major European-based pharmaceutical company (a long-time direct investor in the United States) are regulated by a research agreement with the parent company. Though the research conducted in the United States is directed principally at developing products for the American market, the convergence of market needs around the world has conferred international utility on the R&D work carried out in the United States. In terms of expenditure, the magnitude of R&D conducted in this firm's home country exceeds the R&D in the United States, but, given the relative size of the parent and its American subsidiary, the intensity of R&D activity at both places comes close to being equal. The parent firm, according to its representative at the seminar, has continuously and promptly transferred all of its principal product innovations to the United States. Offsetting this steady inflow of products has been a mounting outflow of technology related to the sophisticated testing for therapeutic efficacy and safety. On balance, and taking the mid-1970's as the point of reference, it appears that

outflows have grown to match inflows closely for this foreign direct investor. As the firm is a mature investor, it appears that the future will see a fairly steady and evenly balanced flow of technology from the subsidiary out to the rest of the company and from the rest of the company back into the American operations.

- Representatives of two newcomer investors--both firms based in Europe--asserted without qualification that their companies are currently employing direct investments as a way of introducing important new pharmaceutical products, discovered and developed in Europe, into the United States. The American subsidiaries of these firms have organized complete scientific and medical staffs to fulfill all the requirements of FDA regulations. If the history of mature investors in the industry is any guide, these subsidiary-directed R&D activities, which were initially aimed at satisfying the FDA regulations, should soon become centers of spontaneous innovation. At this point there may well be an outflow of new technology. At present, as industry experts observed during the seminar, the United States is clearly on the receiving end of new pharmaceutical technology.

- The representative of another mature investor in the United States stressed that his company's experience reflects broad waves of technology inflows and outflows. The parent, headquartered in Europe, has as one of its policies the establishment of full-scale R&D laboratories in all of the world's principal scientific centers. As a consequence of this policy, the parent has carried out a substantial portion of its R&D within its American affiliate, a commitment that extends back several decades. Indeed, using new product development as an indicator of total innovative output, roughly three-quarters of the firm's discoveries originated in its U.S. laboratories during the last 20 years. (Another participant suggested this was by no means unusual, referring to data that indicated a positive correlation between the length of time foreign subsidiaries have been established in the United States and the rate at which they have developed and introduced new drug products.) The firm's discoveries, when they reached the market, clearly augmented the U.S. technological stock. On the other hand, the remarkable fruitfulness of the subsidiary's research effort means that technology has inevitably flowed out of the United States as the subsidiary passed its innovations on to other parts of the parent company. But, of course, this outflow would

never have occurred had not the subsidiary developed a whole series of products to satisfy the U.S. market. At the present time, according to the firm's representative, there appears to be an increasing inflow of product technology from overseas as a result of ever-increasing demands on non-innovative research activities required by government research agencies, principally the FDA. In light of this ebb and flow of product technology, the firm's representative concluded that notions of net technological benefit or loss are not particularly meaningful when judged over any reasonable time span. Based on the experience of his own company, he believes that net technological advantages to the United States or to foreign countries are only temporary and that a far more important point is that these advantages will inevitably spread widely and reasonably promptly throughout the world.

- Finally, the representative of another major European pharmaceutical company, which has recently established a direct investment in the United States, drew attention to what he regarded as a basic asymmetry in the flow of pharmaceutical technology today. On the one hand, because of a conservative regulatory approach to drug development in the United States, innovation is increasingly taking place beyond America's borders, according to a recent study by Wardell and Lasagna.[3] To illustrate this, a participant at the seminar cited 19 of 29 new chemical entities introduced by pharmaceutical manufacturers during 1963 and 1964 of U.S. origin and 10 of foreign origin. By contrast, only 12 of 28 new chemical compounds reaching the market during 1973 and 1974 were of U.S. origin. Though the notion of national origin of pharmaceutical products can be misleading, still, the trend seems inescapable. It suggests the United States will surely become increasingly dependent upon foreign-based innovation for its therapeutic drugs.

Yet, as one seminar participant observed, FDA regulations require all U.S. pharmaceutical companies, whether national or foreign, to discover and develop a wide array of new methodologies for testing the efficacy and safety of new drugs. While such FDA requirements are being adopted by

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3. William M. Wardell and Louis Lasagna, Regulation and Drug Development, American Enterprise Institute for Public Policy Research, Washington, D.C., 1975.

other countries, the United States still remains the center for the development of these methodologies. Moreover, the U.S. pharmaceutical industry, working with university and government scientists, has been particularly progressive in developing new technologies for drug discovery and use, according to the same participant. Not surprisingly, therefore, over the last decade or so, the United States has been exporting this variety of innovation. By way of examples of important outflows, the participant cited American dissemination of (1) the concepts and procedures underlying multicentric clinical trials; (2) the application of statistical techniques to control and judge such trials; and (3) the development of new physical-chemical methods (as opposed to clinical methods) for the testing of therapeutic agents. What the overall picture seems to show, therefore, is that the United States is now a recipient of pharmaceutical product technology and a donor of pharmaceutical testing technology.

Concluding, the seminar representative who had raised this point noted that the asymmetry he was describing was now no longer a matter of choice and initiative by pharmaceutical manufacturers but, rather, the consequence of government regulatory policy. It follows, in his opinion, that the stimulus to technology transfer associated with foreign direct investment, in either direction, is quite secondary to the impetus rooted in compliance with government regulations (which, incidentally, did not have this objective as its motive).

Looking Ahead: The Policy Implications

The seminar participants appeared to endorse the view that the United States is currently experiencing an inflow of product technology and an outflow of what was roughly defined as testing technology, and that such flows are only partly related to foreign direct investment. The representative of one major American pharmaceutical company noted the following worrisome trend: The era of laboratory discoveries of new therapeutic agents has passed and the development of new chemical entities based upon animal pharmacological studies and human clinical investigation no longer suffices. Today, clinical studies of great subtlety and sophistication, together with epidemiological evidence are required prior to market introduction. Wardell and Lasagna have pointed out that as recently as 1974 more than half of all of the industry's

pharmacological studies were being conducted outside the United States.[4] This finding, it was observed, suggests that basic innovational technology is being transferred outside the United States at an increasing pace. In view of the regulatory environment in this country, the shift is understandable, according to one seminar participant. The implication, he argues, is that the United States needs to remain hospitable to foreign investors, because a steadily increasing proportion of critical drug-related R&D is now being conducted abroad.

This issue was considered especially important by the seminar participants. They stated that any moves perceived by foreign interests to be imposing burdensome constraints upon incoming direct investment or upon continuing foreign investors would have predictable and, from the U.S.'s point of view, harmful consequences. Among the reasons cited:

Today, the U.S. pharmaceutical industry spends more than $1 billion annually for research and development. An ever increasing percentage of this expenditure is devoted to work required by the FDA in support of in-line products and new drug approval. Individual companies estimate that as much as 50 percent of their research budget is devoted to this purpose. As funds for pharmaceutical research directed toward new chemical entities are correspondingly reduced, two effects may be seen: (1) the United States is becoming more dependent on the inflow from abroad for new drug discoveries, and (2) the cost of new product introduction and maintenance is discouraging foreign investment.

At this point, discussion at the seminar turned to the kind of legislation or regulation of foreign direct investment--protectionist practices, in other words--in America's drug industry.

Restrictions upon incoming foreign direct investors or upon established foreign investors are likely, the participants agreed, to provoke retaliatory restrictions by foreign governments. As most U.S. pharmaceutical manufacturers maintain substantial overseas operations, their subsidiary networks would be likely targets for retaliation. If, as a

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4. Ibid.

consequence, access to foreign markets is curtailed, U.S. companies would be forced to retreat to serving the American market only. Faced with a much smaller market horizon, pharmaceutical manufacturers would be compelled to cut back on their R&D efforts. When the industry's R&D activity declines, the pace of domestic innovation inevitably slows. This chain of events is a scenario for a national tragedy.

The implications would be even more far-reaching. American-based pharmaceutical companies now conduct a significant share of their pharmacological and clinical research in foreign countries. Both domestic and foreign regulatory requirements have mandated this shift. Hence, therapeutic progress in the United States depends more and more upon study, testing, and trials of new drugs taking place abroad. Should foreign governments, in retaliation to U.S. restrictive practices on foreign direct investment, thwart any foreign-located R&D effort in some way, such moves might well impair some of the pharmaceutical advances that would otherwise be available to the American people.

In short, the threat is double edged. An unsettling of the current climate for foreign investment in the United States could (1) force retrenchment in the level of R&D activity by American pharmaceutical producers and (2) cut off increasingly important pharmaceutical investigation and new therapies developed by foreign companies abroad. Clearly, foreign countries would face similar dangers. The aggregate result would be a loss on all sides.

Another peril exists. Restrictions by the United States upon foreign investors and counter-restrictions by foreign countries upon American investors could cut off the United States from a critical source of information on drug safety. The difference between U.S. and foreign approaches to the regulation of pharmaceutical products accounts for this possibility. As one participant put the issue: the great bulk of the FDA's regulatory effort is directed at monitoring all the steps in the development of a product up to the point of marketing--that is, the FDA concentrates on determining whether a potential product is safe while the product is still in the laboratory or in clinical trial. By contrast, foreign regulatory agencies pay relatively greater attention to the post-marketing effects of drugs. Their philosophy is that the better test of drug

safety is experience with the product once it is in use by a large population of patients. As a result of this alternative approach, some foreign countries tend to have better post-marketing surveillance systems for therapeutic drugs than the United States. Any steps that might impair the access of both the American drug manufacturers and the medical community to this distinctive source of drug safety information would deprive this country of important knowledge it is not now adequately obtaining from U.S. sources. Any significant weakening of the overseas linkages of the internationally-oriented pharmaceutical manufacturers raises this final worrisome possibility.

TABLE 1 Partial List of Pharmaceutical Products Introduced Since 1960 and Marketed in U.S. by Foreign-Based Companies

Trade Name	Generic	Indication	U.S. Company	Parent Company
Librium	chlordiazepoxide	anti-anxiety anti-epileptic	Roche Laboratories Nutley, N.J.	Hoffmann-LaRoche Inc. Basle, Switzerland
Valium	diazepam	anti-anxiety anti-epileptic	Roche Laboratories Nutley, N.J.	Hoffmann-LaRoche Inc. Basle, Switzerland
Inderal	propranalol	hypertension, angina and arrhythymias by b-blockade	Ayerst Laboratories New York, N.Y.	American Home Products originally discovered in England ICI developed in Canada (Ayerst)
Atromid	chlofibrate	artherosclerosis prophylactic by blood cholesterol lowering	Ayerst Laboratories New York, N.Y.	American Home Products originally discovered in England ICI developed in Canada (Ayerst)
Xylocaine	lidocaine	local anaesthetic and cardiac arrhythymias	Astra Pharmaceutical Products, Worcester, Mass.	Astra-AB Stockholm, Sweden
Alupent	metaproterenol	antiasthmatic bronchodilator	Boehringer Ingleheim Ltd. Elmsford, N.Y.	Boehringer Ingleheim Ltd. Germany
Catapres	clonidine	high blood pressure	Boehringer Ingleheim Ltd. Elmsford, N.Y.	Boehringer Ingleheim Ltd. Germany
Bricanyl	terbutalin	antiasthmatic bronchodilator	Astra Pharmaceutical Products, Worcester, Mass.	Astra-AB Stockholm, Sweden
Brethine	terbutalin	antiasthmatic bronchodilator	Ciba Pharmaceutical Co. Summit, N.J.	Ciba-Geigy Corporation Basle, Switzerland
Intal	cromolyn sodium	antiasthmatic	Fisons Corporation Bedford, Mass.	Fisons Ltd. England
Totacillin	ampicillin	bacterial diseases	Beecham Laboratories Div. Beecham Inc. Bristol, Tenn.	Beecham Group Ltd. England
Rifadin	rifampin	pulmonary tuberculosis	Dow Pharmaceuticals Indianapolis, Ind.	Lepetit-Italy (subsequently acquired by Dow Chemical)
Imuran	azathioprine	immunosuppression for transplants	Burroughs Wellcome Co. Research Triangle Park, N.C. (discoverers)	Wellcome Foundation England (developers)
Septra	trimethoprim and sulfamethoxazole	urinary tract infections	Burroughs Wellcome Co. Research Triangle Park, N.C. (discoverers)	Wellcome Foundation England (developers)
Bactrim	trimethoprim and sulfamethoxazole	urinary tract infections	Roche Laboratories Nutley, N.J.	Hoffmann-LaRoche Ltd. Basle, Switzerland
Adriamycin	doxorubicin-HCl	antitumor	Adria Wilmington, Del.	Montedison-Hercules Discovered by Farmitalia Div. of Montedison
Lasix	furosemide	diuretic	Hoechst Pharmaceuticals Inc., New Jersey	Farbwerke Hoechst, A.G. Germany

SOURCE: Foreign Direct Investors in the United States, U.S. Department of Commerce, October 1973, and other published materials.

2. ELECTRONICS, COMPUTERS, AND SCIENTIFIC INSTRUMENTS

As it happens in the other industries examined in the seminars, there are certain special factors in the fields of electronics, computers, and scientific instruments that influence the ways in which technology is transferred. According to the seminar participants, one factor in the transfer of these technologies predominates over those that other industries consider to be vital, such as basic inventions or patents, which are widely disseminated through publications, conferences, conversations among technologists, patent registrations, and movements of highly trained experts between companies. The critical technical element is the "know-how"--the skills and experiences that translate basic knowledge into usable products. Electronics is a process-oriented industry in which knowing how to make a product and make it work are essential to achieving a payoff.

Most of the knowledge is proprietary and, therefore, kept from outsiders. Moreover, because of the rapidity with which basic inventions occur and applied know-how changes in this field, this knowledge is often difficult to acquire or transfer through licensing. The result is that acquisition or new direct investment is often necessary to obtain such knowledge. Since this condition pertains to the industry worldwide, the seminar participants expressed little concern about direct investments by foreign companies in the United States. Some of the participants are associated with companies that are foreign direct investors abroad and, consequently, have a strong interest in unobstructed two-way technology flows. Additionally, many of them are involved in licensing and reciprocal licensing agreements with foreign firms. They are accustomed to continuing exchanges of technology with their counterparts abroad--whether in an active way or by a more passive procedure, such as a "listening-post" or "friendly relationship."

Another reason for this positive attitude toward foreign direct investment stems from the extreme heterogeneity of the industry in the United States. With many firms, some of them quite small, the industry cannot be characterized as an oligopoly. Hence, foreign direct investment in the United States has usually consisted of establishing or acquiring relatively small firms to fill particular niches or functions that are of minor interest to American firms. For their part, U.S. companies have not attempted to achieve the impossible

task of covering the entire field. Moreover, the seminar participants claimed that foreign acquisition has been limited largely to picking up American firms with serious business problems rather than those in a strong position.

Turning to the relationship between technology flows and foreign direct investment, the seminar participants maintained that such investment plays but a minor role in transferring the technology associated with computers, electronics, and scientific instruments. This technology is transferred mainly through a variety of alternate channels, which include scientific publications and meetings, international trade, licensing, technical exchange agreements, and management contracts. Each transfer method carries with it certain virtues and limitations. Foreign direct investment offers the most decisive advantage when it comes to transferring the essential "soft" technology of process engineering, management, and marketing.

Foreign direct investment in the United States often illustrates the classical case of a foreign firm's expansion into the American business community. Usually the company's first venture involves exporting to the United States, then establishing a warehousing and servicing branch to provide regular, orderly, and reliable assistance to its customers. Later on it will decide that the enormous size of the American market, coupled with fears that the United States may adopt protectionist policies against certain imports and that trade conditions at home may become uncertain, justify, first, an assembly plant, then a production facility, and, finally, some applied R&D. Along the way, foreign contributions to U.S. hard and soft technologies in product, process, management, and marketing keep increasing. Hence, the other modes of technology transfer may be perceived as ultimately having a potential for direct investment in the United States, with a consequent impact on technology transfer.

Sony provides a good example of this gradual evolution. After exporting to the United States for a number of years, Sony is about to start up a new assembly plant in Alabama, augmenting its present operation in California, thus moving toward full-fledged involvement in U.S. industry.

In this connection, the seminar participants stated that in the long run large foreign companies will not succeed in America without performing some of their R&D in the United States. At that point, however, U.S. firms will benefit from

the "fallout" of such R&D. It will be more visible and available, and this will result in an increase in the general stock of knowledge within the United States.

Technology Flows in the Industry

There are numerous examples of technology flow in this industry--specifically:

- One of the most sophisticated is the EMI Scanner, a radiological device, using a built-in computer, that produces cross-section images of internal body structures, including the brain, to detect tumors, lesions, and other soft-tissue abnormalties never before visible on conventional x-rays. Introduced in 1972 by Britain's EMI Ltd., it is now assembled at an EMI subsidiary in Illinois.

- Philips N.V. (the Dutch parent company) acquired Magnavox a few years ago. While Magnavox appeared to be having business problems at the time, it had pockets of technological strength in such areas as security and navigation electronics. Already helping Magnavox to overcome problems, Philips N.V. will probably bring its new video-disc technology to its American subsidiary.

- Philips N.V. has also had a long-standing controlling interest in North American Philips. Over the years, the U.S. company has acquired a number of smaller companies, many in the fields of electronics, consumer products, and medical and scientific instruments, as well as some unrelated others, such as animal drugs. Although technology has flowed in both directions between Philips N.V. and Philips N.A., the great preponderance has been toward the United States. This has accelerated in the last two or three years, as the coordination of R&D between the American company and the Dutch parent has been greatly tightened; prior to this, the liaison was quite loose.

- Sony is assembling TV sets in San Diego using its unique Trinitron tube. Although this technology is now well known in the United States, American manufacturers have not attempted to license the tube from Sony because of their commitment to alternative technologies and continuing uncertainty about the superiority of the Trinitron system. The Sony venture was perceived by the seminar participants principally as a Japanese commercial bridgehead in the

United States. Although Sony mainly assembles TV sets in America, the industry believes that the Japanese company will also export its improved production processes into the United States in order to keep down the costs and to overcome the shortages of materials at home. Some seminar participants observed that Sony has taken seriously the threat of U.S. protectionism (e.g., the Hartke-Burke bill), and opened an American plant for this reason rather than for significant costs and technological advantages.

- A "two-flow" example is provided by Plessey's acquisition of Alloys Unlimited, which was having serious business problems during the early 1970's. This American subsidiary is now engaged in electronic product development and applications engineering work for the worldwide activities of Plessey, though it also benefits from the basic research done by the parent company in Britain. Even so, the R&D center of the American subsidiary has worldwide responsibility for such products as semiconductor packaging.

- Germany's Nixdorf AG, which makes computers and other electronic products, acquired an American firm in 1973 for some of the parts it needed for production at home. However, some of the finished products are returned for sale in the United States. With financial support from the German parent, the U.S. subsidiary (Nixdorf Computers, Inc.) continues to expand its applied R&D work.

- In 1974 the consumer electronics division of Motorola was acquired by Matsushita-Panasonic, Japan's largest manufacturer of consumer electric and electronic products. Although Motorola had first-rate Quasar TV set technology, the company had lets its production facilities run down. The Japanese firm is now in a position to bring improved production processes, including automated lines, to a good American technology. Its present contribution, however, still centers on the assembly in the United States of knocked-down products imported from Asia. In this regard, the seminar participants repeatedly emphasized that Japanese investors are bringing new production techniques that are advances on American ones. In the process of expanding and modernizing their industrial base, the Japanese have built very large and modern factories, often with a high degree of automation, to serve domestic and foreign markets. Matsushita-Panasonic, for example, is regarded as a "follower company" that does not innovate much in the area of new products. Instead, the company assumes a

strong market position after a reasonable period of time by simplifying the design and production of recently introduced products, thereby facilitating automation and sharply reducing manufacturing costs. This kind of technological innovation is introduced in large foreign plants such as the ones started or acquired in the United States. The seminar participants saw this as a specific example of how foreign investors contribute to American manufacturing capability and efficiency by reducing material and labor requirements--an important development in a period of material shortages, inflation, and keen international competition. (In connection with the subject of production technology, one seminar participant noted that some Japanese investors are reluctant to show their factories to visitors who could learn about their production methods--a practice that many American firms have provided for foreign engineers and managers eager to learn about U.S. production methods since World War II.)

- Akai America is an example of how foreigners often bring in "soft" technologies in the field of marketing. The firm is a Japanese-owned subsidiary that engages not only in product development, but also in training its U.S. personnel to service the warranties connected with the sale of hi-fi products imported from Japan.

- The participation of Fujitsu, Ltd., in Amdahl was the main example cited of a technology outflow resulting from foreign direct investment. Fujitsu is the leading Japanese computer firm, and Amdahl is a small company founded by a former IBM employee to develop advanced computers. In the early 1970's Amdahl's difficulty in raising venture capital in the U.S. market imperiled the new firm. Fujitsu bought 22 percent of Amdahl and presently has the right to increase its participation to 39 percent. While the survival of Amdahl benefits American technology--and, therefore, may be viewed as augmenting U.S. technological stock--it also represents a case of outflow to a large Japanese computer firm that gained access to advanced American computer technology. Fujitsu's participation in Amdahl enhances Japan's capacity to manufacture such computers and to eventually threaten U.S. export markets in Asia.

- In the industrial process-control field, one seminar participant concluded that until recently technology outflows due to foreign direct investment in the United States had been too small to be significant. However, he mentioned that

Farbwerke Hoechst had recently invested in South Carolina textile plants where computers were being used in process control. The foreign firm is now implementing this advance in West Germany, using U.S. computers for the purpose. In this way, U.S. equipment is being introduced in an old industry where it was considered likely that German computer makers would be dominant. The result has been a net economic gain for the United States.

Despite the paucity of examples of technology outflows from foreign direct investment, the seminar participants decided there were a number of cases where foreign firms have used their American operation--whether acquired or started from scratch--to reinforce their own domestic R&D capability and, thereby, expanded their "global reach," with a concomitant and possibly negative impact on U.S. competitiveness around the world.

Assessing the Balance of Technology Flows

In considering the overall balance between inward and outward flows in this segment of American industry, the seminar participants tended to form an intuitive consensus that the net technology flow associated with foreign direct investment was inward. However, they did not consider it possible to provide any substantiation of this or make meaningful judgments as to the positive or negative value of the net flow to the United States. Yet they seemed to agree that foreign technology flows into the United States are increasing relative to the past when American technology predominated. Still, the movement is not exclusively related to foreign direct investment in the United States because technology still flows mainly through imports, technical agreements, and licensing arrangements.

Notwithstanding, the participants were not overly concerned with the precise balance of technological flows. Instead, they stressed that the narrowing of the "technology gap" between the United States and other advanced industrial countries--whether achieved by foreign direct investment or by other means--is highly desirable. For one thing, it fosters the sale of U.S. products abroad when these products depend on the demands of increasingly sophisticated customers overseas. Besides, foreign technological sophistication enhances the quality of the technical exchanges among advanced countries--a situation that redounds to the

advantage of the United States, which cannot realistically claim to be self-sufficient in all technologies.

Technology as a Motivating Force

The seminar participants said strongly that technology is only one of many forces that motivate foreign direct investment in this complex industry, and that at present it is probably not the main one. Some of the other forces that the participants listed:

- Marketing considerations--namely, to be close to the large and affluent American market, which is considered the "vanguard" in which new products acquire a sufficient production base as well as market testing before introduction elsewhere.[5] In addition, it is considered important to locate in the United States to adapt foreign products to American needs and to provide the prompt, reliable service expected by American customers.

- The effect of the United States as a "melting pot" where technologies are rapidly diffused, understood, and shared--at least as far as general scientific knowledge is concerned. This is a function of the strong infrastructure of educational, research, professional, and communications systems operating in this country.

- The relative economic conservatism and political stability of the United States. These are attractive to those foreign investors who are disturbed by certain political, economic, and social conditions in the world--e.g., in Western Europe where many restrictions exist on pricing and capital movements and where workers and governments are obtaining greater managerial, supervisory, and countervailing powers on boards of directors and day-to-day operations.

- The devaluations of the dollar in 1971 and 1973, as well as the high rate of inflation abroad that has increased foreign costs and prices absolutely and relatively, have

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5. In a study by Michael Jedel and Duane Kujawa of Georgia State University, Management and Employment Practices of Foreign Direct Investors in the United States, Office of International Finance and Investment, U.S. Department of Commerce, March 1976, a majority of the respondents also emphasized this argument.

been strong incentives for foreign investment in the United States. To many foreign companies and individuals, direct investment in the United States appears attractive--especially when coupled with the bargain acquisition prices of some distressed American companies.

Although the seminar participants claimed that technology was not now a major motivating force, they stated that this situation could be changing. Thus, if foreign firms want to obtain such advanced American technology as the new integrated circuit technology used in computers, radios, TV sets, and digital watches, they now have to develop it in the United States ("where the action is"), acquire American companies, or team up with them. Already some foreign acquisitions of U.S. firms reflect the critical need to move fast in new areas of technology. Digital watches provide a good example, because American technology is way ahead in this field and foreigners (e.g., the Japanese) can hardly hope to catch up by starting from scratch. At the same time, intense competition in the United States makes some American manufacturers quite vulnerable to takeover or at least places them in need of further financial support through joint ventures in order to expand production and research. Thus, Frontier Electronics, for instance, was acquired by a Japanese firm eager to acquire digital watch technology. Another case in point is Murata, a Japanese company that has invested in Oak Industries to obtain the ferrites for its electronic products.

Foreign Control and Technology Transfers

No conclusive evidence was presented during the seminar on the extent to which foreign control affects technology transfer, apart from the obvious point that majority or full ownership provides foreigners with more leeway than minority arrangements and that what ultimately determines whether the foreign firm will control the situation is how critical its involvement is perceived to be. Thus, an American firm badly pressed for venture capital, which it can only obtain from outsiders, will almost certainly have to grant its foreign partner various technological concessions (as in the Amdahl-Fujitsu case).

However, the plight of the small technology-based company should not be overstressed. Some small companies have had problems

that are completely unrelated to foreign direct investment; others have been in such a condition that only a foreign investor could save them. Some of these firms could not have been rescued by large American companies. Antitrust considerations would have forbidden or, at least, complicated such acquisitions as reducing competition in the United States. By contrast, foreign acquisition tends to maintain and even enhance the number and quality of competitors.

Capital Infusions from Abroad

The financial contribution of foreign investors--mainly West European and Japanese--was stressed repeatedly at this seminar. The consensus of opinion seemed to be that foreign investors have made an important contribution to American R&D by maintaining or even upgrading it through capital infusions. As the seminar participants saw it, the United States now suffers from a lack of venture capital, following the major decline in the stock market since 1968; and the American banking community is not very active or adventuresome in this area.

Foreigners, however, manage to bring in capital more readily because (1) the United States is a high priority market; (2) foreign banks--private and public--are more accustomed to providing intermediate and long-term funds for expansion (cheap government loans as well as subsidies are also often available in this connection); (3) like Americans, they have ready access to the Eurodollar market; (4) they are accustomed to working with higher debt-equity ratios, which minimize their need for profits as a source of investment funds.

In this context, U.S. firms, faced with a choice between going under for lack of domestic venture capital or accepting foreign participation, normally choose the latter--and this situation promises to last as long as America's financial markets remain weak.

To the extent that foreign investors succeed in rescuing these companies with infusions of capital, technology, and management, the American economy will benefit because this helps maintain--and possibly improve--the existing U.S. technological stock. Seen from this perspective, the Amdahl-Fujitsu combination represents a case of augmenting the U.S. technological stock through a financial rather than a technology inflow. Fujitsu, which had received a $100 million subsidy from the Japanese government to develop similar computers, teamed up with Amdahl--

first, in 1971, by sharing production-engineering information and then, in 1972, by infusing some $22 million into Amdahl. A cross-licensing agreement was signed in 1972, resulting in what appeared to be essentially an outflow favoring the Japanese partner, and in 1973 a joint venture for international sales was announced. But when IBM's engineering rendered its real-memory model obsolete, Amdahl needed some $20 million to $30 million more to develop new products. A public sale of stock failed and Amdahl turned again to Fujitsu to double its investment in 1974. Still, it appears that Fujitsu did not take undue advantage of Amdahl's situation, realizing that an onerous, one-sided transaction would have ultimately impaired the American firm's contribution. (There also is German and American money invested in Amdahl.)

Even so, one seminar participant deplored the absence of a national program or any "solutions" to prevent foreign takeovers of weak American companies. He noted that Amdahl had to cross-license its technology with that of Fujitsu on a royalty-free basis. Should the link have been with, say, Honeywell, the business would have at least stayed in U.S. hands. After 1971 it was clear that American companies and investors were not interested in backing Amdahl, possibly because it was not considered profitable. Fujitsu concluded otherwise. It is not clear at this point in the Amdahl-Fujitsu case, at least, whether foreign investors have a better track record of spotting and backing promising newcomers in this highly competitive industrial sector.

Several other examples were cited of the way in which foreign investors have contributed to American R&D:

- I/O Devices, a small New Jersey electronics firm, was operating at a loss. This led it to cede 53 percent ownership to Japan's Ricoh Company in 1972 for close to $800,000, part of which was paid by cancelling a security owed by Ricoh. This illustrates again the case of a foreign firm interested in nascent high technology and acquiring it through financial links with an American firm experiencing serious difficulties.

- Computer Optics granted a license to Daini Seikosha when this Japanese company agreed to cancel a $135,000 debt. By October 1975, this firm and another Japanese firm held 94 percent of Computer Optics, which was making cathode-ray tube displays but experiencing problems in raising capital.

• Computest was acquired by West Germany's Siemens AG for close to $5 million in 1973. This U.S. maker of digital computer core memories and test equipment suffered from a sales lag. At the same time, the emergence of new memory technologies as well as changing customer requirements demanded that large investments had to be made in R&D, and Siemens AG helped to finance these.

• Dickson Electronics Corporation made zener diodes, test-recovery rectifiers, tantalum capacitors, and hybrid circuits; it also held a variety of patents relating to semiconductors and electronic circuits--typically in competition with many other firms and not with any particularly unique technology. It had problems with sales and profits until 1973. Its product line remained narrow, and its debt structure was uncomfortable, given the highly volatile nature of the industry. It needed a wealthy parent company for survival and growth; and it found it in Siemens Capital Corporation, a subsidiary of Siemens AG, which made a successful tender for Dickson in 1974.

One intriguing question centered on why foreigners can make a go of U.S. firms and plants that Americans can no longer operate profitably. While some of the seminar participants cautioned against premature answers to this question because experience in such matters is still relatively new, there was agreement that the success of foreign takeovers and partnerships could be explained in terms of manufacturing and marketing contributions. In some cases, Japanese firms sometimes bring in improved production processes refined at home. On the marketing side, many acquisitions are of firms that manufacture intermediate products for shipment back to the home country, where these are incorporated into final products. So, in this context, the U.S. subsidiaries obtain captive foreign markets which they did not have before. Besides, by investing in the United States for assembly or production, foreigners may be able to sell their wares in America, where they were once restrained by various "Buy American" laws and clauses related to national defense and market protection. The Siemens and Nixdorf acquisitions seem to belong in this category.

Still, it was suggested in the seminar that American firms may be less capable of financing new R&D and modernizing old production facilities because of the previous onslaught of Japanese imports in this country, which reduced U.S. profit margins in consumer electronics. No doubt this helped bring

about the acquisition of the consumer electronics divisions of Magnavox and Motorola. Hence, foreign direct investment is partly attributable to the international trade offensive from abroad.

Looking Ahead: The Policy Implications

In drawing conclusions about the overall impact of foreign direct investment in the U.S. computer and electronics sector, the seminar participants agreed that until now foreign investors have contributed mainly in two ways:

1. Through their infusion of venture capital.

2. By introducing new technologies (if only through imports). These technologies have served to spur American research because they have forced U.S. firms to upgrade their technological capabilities in order to be competitive.

But the participants also pointed out that foreign investors have introduced new products in the United States and that they have helped keep prices down by locating in the United States and, thereby, offsetting the rising cost of foreign imports resulting from the two successive devaluations of the dollar, increasing labor costs abroad, and soaring international transportation rates.

The seminar participants identified two areas where foreign technology is growing rapidly and may ultimately lead to additional foreign investments in the United States, even though most of it is now transferred through imports.

1. A study by the Automation Research Council has revealed that the West Germans and Japanese are investing heavily in automation, with government support, and thus may become even fiercer competitors. They are developing this technology in order to reduce in-process inventories as well as to reduce labor costs aimed at diversifying their export capabilities, and, in Japan, out of the need to grow with non-polluting industries. The participants agreed that this development gives additional substance to the need to maintain open technology flows so that U.S. firms can benefit from technical developments in other parts of the world.

2. British, French, German, and Dutch companies are strong in the medical equipment field, where they have developed advanced scanners and pattern-readers that are now exported to the United States. The participants emphasized that the United States can only benefit from greater technological exchanges with foreign firms in such developments.

The seminar participants concluded that, as a matter of public policy, it would be unwise to restrict technology transfers through direct investment or any other means (outside of a few defense-related sectors). The participants stated that the United States cannot become self-sufficient in technology but must specialize in what it can do best and obtain the rest from abroad, possibly through direct investment in the United States. After all, the electronics field is large, complex, and changing, and it contains many niches for all sorts of companies, including those from abroad.

3. NON-ELECTRICAL MACHINERY

In examining the relationship between foreign direct investment and technology transfer in the non-electrical machinery industry, it is important to recognize that there are different kinds of technology and that each holds special problems associated with its transfer. These are presented below as they were summarized by one of the seminar participants.

TYPE OF TECHNOLOGY	CHRONOLOGY	SPECIAL TRANSFER PROBLEMS
Product	First phase	Relatively standard and easy to transfer through licensing; worldwide spread
Application	Second phase	Very difficult to transfer; very localized in terms of special needs; little international spread; need to be close to customers
Process	Third phase	Originates from many sources; proprietary technology easier to transfer through subsidiaries than through licensees

The essential point about this breakdown is that, for this industry at least, foreign direct investment is often a better way of transferring or acquiring process and application technologies because their successful transplantation is closely linked to local conditions and cultural traditions. Product technology, on the other hand, is more readily transferable through licensing.

During the seminar the point was repeatedly made that--as in many other industries--new technologies quickly spread around the world in one form or another--through imports, licensing, direct investment, etc.--unless they are closely related to special local circumstances (such as tractors suited only for small landholdings). In this respect, consider the increased attempts by multinational firms to develop industrial machinery

that can be produced and sold in many markets with relatively minor adaptations, instead of the practice of each national subsidiary developing its own products to meet the needs of the particular country.

The seminar participants stressed the importance of timing in the transfer of this kind of industrial technology. There seems little doubt that sooner or later most foreign countries will learn how to make a particular piece of equipment, but for some of them it is salient to know how to do it now. Hence, such moves as acquiring American firms or investing anew in the United States need to be understood in terms of the perceived urgency to remain competitive. This applies equally to U.S. firms buying or licensing from foreign firms.

Thus, the seminar participants agreed that there were some prevalent myths about technology transfer that ought to be dispelled:

- That technology can be contained and concealed, when, in fact, there are numerous leaks and disclosures through publications, symposia, personnel mobility, "reverse engineering" of competitive products, and specialty houses that sell machinery. Process technology is easier to conceal.

- That the United States can be self-sufficient in technology, when, in fact, the resources do not exist for achieving this; and, in any case, foreign firms cannot be stopped from developing their real technological strengths.

- That foreign firms buy into distressed U.S. firms at bargain prices, with no subsequent advantages to American technology, when, in fact, there are sometimes no alternatives to this. Besides, these firms have often coupled their technology to a similar technology in the United States, thereby improving the overall result. For example, the Japanese were able to improve on automobile tire technology developed in the United States, thereby reducing the cost of tires used in America's farm and construction equipment. The plain truth is, the seminar participants observed, the birth, growth, decline, and death of individual American firms constitutes a normal business cycle that is only partly related to foreign direct investment.

- That a foreign company typically drains off more technology than it supplies, when, in fact, the preponderance of cases features a net flow of technology outward from the corporate home base.

It is not surprising that the participants at this seminar, although aware of the competition generated by non-U.S. technology, generally favored such inflows and were not troubled by the concomitant outflows. Moreover, while they stressed that direct investment is not now the major channel for such transfers, they concluded that its importance was increasing.

Technology Flows in the Industry

Although the seminar participants recognized that foreigners contributed to American technology in many ways not linked to direct investment--e.g., through imports, technical exchanges and licensing with foreign firms, and the "listening-post" function of U.S. subsidiaries abroad--they identified a number of positive inflows in addition to those made by such old-timers as the AB SKF Sweden, the giant roller bearing company.

- Canada's International Nickel has been in the lead in specialty nickel alloys, developing most of that technology in the United States and exporting abroad. It also has cross-licensing arrangements with the French company Le Nickel.

- Canada's Massey-Ferguson does R&D work in the United States that is related to farm and construction equipment; its United Kingdom subsidiary, Perkins Engines, engages in assembly and manufacturing in the United States although Perkins' R&D is done in Great Britain.

- Kockum Industries, Inc., a Swedish sawmill equipment firm, produces and handles a variety of products in the United States, some of which are imported from Sweden and Canada. The R&D mission at the U.S. operation concentrates on wood chippers and chip-handling equipment (possibly as a reflection of special American needs in this area) and serves the company's worldwide markets for these products.

- Japan's Nippon Miniature Bearing Company has acquired a plant in California previously owned by SKF Industries, Inc., the U.S. subsidiary of AB SKF Sweden. It is too soon to tell whether the production improvements and employee-motivation techniques--the stress on job security and teamwork and loyalty to the firm--imported from Japan will really pay off in terms of reduced production costs. (See section 2 for a discussion of Japanese production innovations in the electronics industry.)

• The long-wall coal mining process has been used in Europe and Japan for many years because the configuration of mines there is usually deeper and narrower than those in the United States. Now that this technology is beginning to be used in those American mines which resemble many coal mines elsewhere, this equipment is being imported (e.g., from Hemscheidt of West Germany) and/or licensed to American firms that also represent them (e.g., Joy, Ingersoll-Rand). This is spurring U.S. technological development; in fact, the U.S. Bureau of Mines is subsidizing research in this field.

• European firms are strong in the compaction of earth materials and have entered the U.S. market through imports and licensing arrangements. West Germany's Vibromax and Sweden's Vibro Plus have licensed American firms to produce their vibratory compaction equipment.

In addition, the seminar participants discussed a more general kind of inflow which results when foreign processes and products are brought into the United States--namely, that these not only help spur the development of U.S. technology by exposing it to greater competition, but they educate American technologists about the "state of the art" elsewhere and give them a better slant on foreign products under actual operating conditions. In this way, Americans can learn more about the design and performance of a new product, and they can also observe how it meets new consumer needs. For example, cooling systems account for most of the failures in tractor operations, and the availability of the Deutz air-cooled engine (manufactured by Klockner-Humboldt-Deutz in West Germany) provided an impetus for improving this critical component in American tractors.

Europeans put more emphasis on careful design for quality performance and on esthetics, said a participant at the seminar, while Americans stress being functional and achieving economical performance. Exposure to European products may help spur American production in this direction, too.

In short, as one participant pointed out, when a foreign firm market tests a technical innovation in the United States and proves it successful through expanding sales, it has an important demonstration effect that can lead to technological imitation.

A few cases of negative outflows were mentioned during the seminar, although the participants recognized that most of

these were balanced by exchanges between cross-licensors and between parent and subsidiary companies.

- Envirotech, a U.S. company in the pollution control field, has recently sold 25 percent of its stock, as well as a majority of its European facilities, to a Dutch investment firm. Envirotech apparently needed cash, while the Dutch firm wanted to gain access to the technology.

- West Germany's Volkswagen acquired Delanair in 1969 to provide its imported cars with air-conditioners. As this is an area where Europe remains weak, the U.S. technology of automobile air-conditioners may well find its way overseas, even though Europe has not displayed any demand for this equipment.

- Milroy-Silor is a 50-50 joint venture between Silor of France and Milroy Optical of the United States. The latter has a desirable process technology for making soft contact lenses which the French firm wanted to acquire for its own line.

- Howmet was acquired by the French company Pechiney after the American firm had developed the technology of high-temperature precision castings for gas turbines. For its part, Pechiney has brought advanced aluminum-reduction processes to the United States.

- The acquisition of Sohio by British Petroleum (BP) combines the relative strengths of the two giant companies. The British firm is strong in exploration and supply, while Sohio has the necessary distribution network. In technology, Sohio has kept its own R&D capability in petrochemicals, which is now available to the British, while BP is developing its California-based BP-Alaska exploration technology.

- One seminar participant regarded the U.S. Government as assisting the outflow of American technology through formal exchanges with the U.S.S.R. in the field of environmental protection.

Assessing the Balance of Technology Flows

In a number of cases the seminar participants were unable to determine the net direction of technology flow between a foreign parent company and its U.S. subsidiary because of

continuing interchanges whose nature varied substantially over time. In the food-machinery industry, for example, foreign firms such as Baker-Perkins have had to invest in this country and elsewhere because of the need to adapt products and processes to local conditions. (Bread, it seems, varies from country to country in its content, texture, and size.) Therefore, an R&D application capability is needed by most foreign subsidiaries, although technological exchanges obviously take place between the British parent company and the subsidiaries.

However, several participants pointed out that such transfers do not come easily once the subsidiary has acquired some research autonomy. Then a chauvanist attitude of "Not Invented Here" often leads to ignoring or rejecting technologies developed in other parts of the global organization. This, of course, can happen in any industry and suggests the general observation that technology transfers among parts of a multinational corporation, whether inward or outward, should not be assumed to be simple or frictionless unless the company has a strong centralized structure. Besides, many exchanges between the foreign parent company and its American subsidiary are on a paying basis, so that transfers of technology achieved this way are not free.

The seminar participants were unable to assess the balance in other cases:

- Pollution-control equipment, where the Europeans had an early edge. The activated-sludge process, for instance, was developed in England before World War II, and there is the example of Dorr, the Dutch company, which upgraded U.S. technology by merging with Olive Filter. However, since the Clean Water Act of 1965, U.S. regulations and subsidies have encouraged and supported Americans to outstrip the Europeans in applied anti-pollution technology, particularly in process control.

In this field the seminar participants also identified two cases of foreign direct investment that have not succeeded:

1. The French firm Degremont teamed up with Research Cottrell because the American company developed financial problems. But the French technology was not unique, and, confronted by competition, this joint venture has not been successful.

2. The German water-treatment firm Passavant launched Beloit-Passavant Corporation in order to break into the lucrative municipal wastewater market. The Germans contributed process know-how, although it was not unique. This joint venture ultimately failed for lack of adequate application marketing, which is critical in this area. However, Passavant still operates in the United States, employing a high proportion of technologists.

- Sciaky Brothers, Inc., provides an interesting illustration of the technological interchange between the U.S. and foreign parts of a company. Originally a French firm, it moved to the United States in World War II, then restored its French operations after the war. (The whole enterprise is owned by one family, now naturalized U.S. citizens.) The firm originally brought over French technology, but new welding processes were also developed in France after the war--principally the electron-beam welding process invented by France's atomic energy agency, but commercialized by Sciaky-France, and then transferred to the United States. In its applications to U.S. industry, the American branch has refined the imported technology, thereby leading to continual exchanges between the French and American branches of the company. Both sides maintain R&D facilities, interchanging among themselves and licensing abroad. Recently, American automobile makers have been producing smaller cars that require closer tolerances and different demands on body design and construction (including welding). Since European car manufacturers have long made such cars under close tolerances, the French-developed Sciaky welding technology for compact cars is being imported to the United States. Even so, the technology flow is not just from France to America. In the case of electron-beam welding of transmission parts in Borg-Warner's factory in the United Kingdom--an early mass production application--all of the technical support, as well as the machines, come from Sciaky-U.S.

- High-pressure hydraulics used for cranes, construction equipment, and elevators is a technology in which Europeans are particularly strong. Their machines are usually quieter and capable of meeting more stringent noise-abatement regulations. Both Poclain of France and Liebherr of West Germany export to the United States as well as assemble their products in an American plant.

• Textile machinery has received a boost from the European lead in fashion and new textile designs, with the double-knit, for example, providing a boon to Italian knitting machinery. In fact, if imports of such machines continue apace, the Italians may shift some of their production to the United States.

• Fiat-Allis, Inc., is a recent joint venture of the Italian firm Fiat (2/3 ownership) and the American Allis-Chalmers (1/3 owner). These two leading companies complement each other in terms of products and geographic coverage: Fiat is strong in small machines, especially in Europe as well as in Europe's traditional markets abroad, while Allis-Chalmers is well-established in North America with large machines and exemplary expertise in transmissions, hydraulic systems, and soil and rock dynamics.

Technology as a Motivating Force

Many of the examples provided by the seminar participants illustrate that foreign firms usually enter the American market or invest in the United States for reasons not immediately related to technology transfer. However, a number of foreign investors have engaged in technology transfer as their American experience developed. A market-oriented entry through imports is often followed by the setting up of warehouses, servicing centers, assembly plants, and, ultimately, some local production facilities in order to manufacture products better adapted to the American market. Thus, new technology may or may not exist, but it is usually co-mingled with marketing, financial, and politico-economic considerations.

For that matter, several seminar participants observed that some foreign firms were making direct investments in the United States with the encouragement of their American customers. These customers had turned to foreign companies to supplement or complement American output when they had encountered supply shortages. Now that production costs have increased abroad even faster than in the United States, the foreign firms are expanding their assembly and manufacturing facilities within the U.S. Although many foreign-designed products are very good indeed, they do not present significant technological advantages. Still, they enable U.S. companies to concentrate on the more technologically advanced components of their own products. They also enable U.S. firms to start producing sooner, because no time or money needs to be invested in designing and tooling up for components bought abroad. Thus,

John Deere buys crawler-tractor components from Berco and Italtractor in Italy and from Tractor Teknik in West Germany; it formerly purchased undercarriages for excavators from Hitachi in Japan.

Another force influencing foreign direct investment is increasing production costs abroad. Rising costs also are pushing foreign firms to increase their use of sources in the United States for their American assembly operations. Production processes in the United States are influenced by the labor situation abroad, as in the case of the Belgian firm Bekaert, which is seeking to eliminate night work in its highly automated steel-wire plants in Belgium. Such pressures increase the prospects for transfer of advanced processes to the United States.

Yet it is important to note that foreign firms need not always invest in the United States to obtain technology that may sometimes be obtained through other means, such as maintaining "listening posts" to keep up with American technological developments and to locate worthwhile American licensors and partners.

Foreign Control and Technology Transfers

It needs to be restated that technology transfer depends very much on the nature of the company. Thus, in the U.S. ball-bearing industry, there are companies such as Timken with a worldwide orientation and a high degree of centralization in terms of exchanging technologies with its subsidiaries. There are also U.S. firms such as Fafnir (Textron) that have a largely domestic orientation. Then, there is SKF Industries (affiliated by ownership with the Swedish multinational) which retains complete domestic control of its operation and has fully developed its production and research facilities in the United States, to the point where some products and technology cannot be freely transmitted abroad because these are integral to America's defense. Finally, Japan's miniature ball-bearing makers have demonstrated remarkable success in the U.S. market with their imports; but at least one of these firms found it necessary to produce in the U.S., acquiring a plant in California, in order to be closer to its market and to get into some defense-related business closed to foreign-based firms. Similarly, West Germany's FAG-Kugelfischer, the largest European ball-bearing firm after SKF, has acquired Norma-Hoffman in the United States, while Hoover Bearing Company of the United States is associated with Japan's NSK, which ultimately took over Hoover-NSK.

In the bearings industry, for one, R&D appears to "travel with the dollar"--that is, R&D takes place where the financing originates. As an example, the U.S. subsidiary of AB SKF is essentially independent in its research efforts because of the relative financial autonomy it has achieved over time. Still, AB SKF research also takes place in Sweden and the Netherlands, and the results are made known to the firm's units wherever this is not restricted by governmental policy. Such restrictions would prevail, for instance, for the work done by SKF for jet engine bearings in the United States.

Looking Ahead: The Policy Implications

In considering future trends in technology flows, the seminar participants concluded that since the development of technology in the non-electrical machinery field takes place in many industrialized countries, and that its spread is facilitated by multinational companies, it can no longer be associated with a particular nationality and its two-way flows are bound to continue. Moreover, they claimed the United States provides a stimulating environment for R&D. Interchange is common and relatively easy in the United States, and government R&D contracts are available for certain types of advanced new applications, such as defense-related products--precisely where private funding is difficult to obtain. Hence, the seminar participants expect foreigners to be increasingly attracted to doing research in the vast U.S. market, particularly because it calls for many special products and process adaptations.

This view was supported by a report by Jedel and Kujawa of Georgia State University (see page 31). This report notes that of eleven firms or subsidiaries in the non-electrical machinery field, seven plan to increase their R&D in the United States, while four expect to keep it at present levels. This includes product and process R&D as well as the movement of management and marketing skills, a good part of which is already transferred through informal exchanges rather than through formal licensing or other arrangements.

With regard to this trend, however, one seminar participant cautioned that foreign firms with strong international market positions, such as SKF, International Nickel, and Fiat, may diffuse the technological innovations they have made in the United States to their foreign subsidiaries, thereby enhancing their competitive positions against U.S. firms. In considering the implications of this for the non-electrical machinery

sector, the participants reached a consensus on three points:

1. Barring foreign investment in the United States would not have an immediate impact on the level of technology available, because much of it could still be obtained through imports, licensing, and other general processes that diffuse technology--at least, basic inventions. But there would be problems regarding the financing of some small U.S. firms that cannot obtain venture capital domestically for their advanced technologies, the maintenance and creation of jobs, and the relations with foreign countries that would still accept American direct investments.

2. The continuing shortage of capital, together with the need for energy-saving and material-saving machinery, will require the United States to borrow more from European and Japanese technologies in sectors where these have forged ahead--mostly because Europe and Japan had to come to grips with shortages of energy and raw materials before the United States. These factors, together with the increasingly higher cost of R&D, virtually direct the U.S. non-electrical machinery industry to accept an international division of labor, avoid unnecessary duplication of products, and acquire some of America's technology from abroad, whether through imports, licensing, or direct investment. One seminar participant warned that an international division of labor also could lead to the reinforcement of oligopoly positions by U.S. and foreign firms.

3. The United States needs to support foreign direct investment, although this does not exclude using U.S. technology outflows as a powerful bargaining tool in international economic relations--in negotiating with less developed countries in exchange for their raw materials, for example, and with developed countries (including centrally planned economies) to make sure that they will allow the export of their technologies.

4. PETROCHEMICALS AND THEIR DERIVATIVES

Like the other three industries examined in this series of seminars, petrochemicals and their derivative products constitute an international industry where foreign direct investment is not perceived as the principal means of transferring technology. Rather, as several participants in this seminar emphasized, the major routes by which petrochemical technology is transferred from one nation to another are (1) the open literature, through which the basic scientific information flows, and (2) the licensing and sale of technology, which enables commercial technology to be transferred. During the seminar there was general agreement that most petrochemical processes are openly licensed and that within the industry almost everything is licensed to almost everyone. Consequently, little incentive exists for a foreign firm to acquire an American company for the specific purpose of obtaining its technology.

This situation is the natural result of the way the petrochemical industry has evolved. In a 1968 study of technological transfer in the industry, Robert Stobaugh found that during the early phases in the development of a typical petrochemical product, most of the production facilities are owned by the innovating firm in its home country.[6] At the beginning the company has a monopoly on the technology. Over time, however, the technology is disseminated by licensing or selling it to other firms. Additionally, some competing firms become capable of developing the technology independently. As a consequence, the innovating firm loses its monopoly over the technology, and the proportion of the world's productive capacity it owned declines in time. As markets for the product develop in other countries, the technology is licensed or sold to companies outside of the originating firm's home country. These companies, in turn, build productive capacity in their own countries. Not surprisingly, then, the technology is diffused abroad, and the originating firm loses some or much of the proportion of the world capacity it previously enjoyed. The innovating firm often contributes to the international diffusion of technology and

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6. Robert B. Stobaugh, "The Product Life Cycle, U.S. Exports, and International Investment," Unpublished D.B.A. thesis, Harvard Business School, 1968.

productive capacity by making foreign direct investments, especially in less developed countries. But the capacity created in this way is typically small relative to the capacity created by licensing.

The most important single factor determining when production of a particular petrochemical product can be initiated in a country, Stobaugh has stated, is the size of the domestic market. Because the United States is the world's largest market for organic chemicals, it is most often the first country to commercialize the technology required to produce a new petrochemical product. This is not to say that development of the basic science of the product necessarily occurred in the United States. At times it did not. However, the development of the technology required to produce a petrochemical product in commercial quantities frequently took place in the United states, and, likewise, commercial production began in the United States.

Although the United States was the first country to commercialize the production of a high percentage of petrochemical products, by no means was it first with all such products. Because of the buying power of the American market, in those cases where commercialization occurred abroad, the technology was rapidly introduced in the United States, usually by means of licensing or sale to local producers. Stobaugh's data, though incomplete, suggest that prior to World War II initial commercialization of petrochemical products most often occurred in Germany rather than the United States, but that the United States tended to lead in commercialization in the post-war years.

Technology Flows in the Industry

The seminar participants agreed that they could identify no specific examples of a major foreign investment being made in the United States out of a desire to acquire petrochemical technology per se. Rather, the investment was based upon such commercial considerations as gaining access to the large American market and enjoying the advantages of operating in that market. Moreover, although the participants cited numerous cases where technology was brought into the United States by the route of foreign direct investment--listing Montedison, Bayer-Monsanto (Mobay), Dutch State Mines-Columbia Nitrogen and Nipro, and AKZO-International Salt--the technology inflow was much less important a consideration than the commercial and market factors.

The issue of whether or not technology is transferred by means of direct investment is quite complicated in some cases Shell Oil Company is a case in point.[7] Shell Oil is a U.S. corporation, though a majority of its common stock is beneficially owned by Shell Petroleum N.V., a member of the Royal Dutch/Shell Group. Thus, Shell Oil is, by U.S. Government standards, a direct investment in America by a foreign corporation. Furthermore, both Shell Oil and a member of the Royal Dutch/Shell Group perform active R&D work and maintain a cost-sharing agreement requiring each to undertake certain research for--and exchanges with--the other. On the surface, at least, it would appear that Shell Oil is an example of a two-way transfer of technology resulting from foreign direct investment in the United States.

As it happens, though, the picture is not as simple as this. Relations between Shell Oil and members of the Royal Dutch/Shell Group proceed at arm's length. The cost-sharing of research programs is renegotiated annually. Outside of that agreement, certain technology which is developed by Shell Oil in the United States is licensed or sold to Royal Dutch/Shell in much the same way it would be to any other oil or petrochemical firm. Furthermore, Royal Dutch/Shell receives no preferential treatment in the licensing or selling arrangement. Likewise, certain technology which is developed by the Royal Dutch/Shell Group outside of the United States, and not under the cost-sharing agreement, is licensed to Shell Oil in exactly the same manner that it would be licensed to any other American company.

The case of Shell Oil-Royal Dutch/Shell is not unique in the oil or petrochemical industries. In 1969, British Petroleum (BP), which is principally owned by the British government, bought an interest in Standard Oil of Ohio (Sohio). Thus, Sohio, by U.S. Government standards, is a direct investment of BP. The motivation behind BP's investment was relatively straightforward: BP had discovered crude oil in Alaska and needed a U.S. marketing outlet, while Sohio was short of crude stock. Combining BP's crude with Sohio's outlets was a logical solution to each company's singular problem.

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7. K. Beaton, Enterprise in Oil (Appleton-Century-Crofts, 1957) and F. Gerrotson, A History of the Royal Dutch (E. J. Brill, 1953) Volume III.

Both BP and Sohio have licensed technologies to each other--though in most cases these licensing arrangements predate BP's acquisition of Sohio. Could it be said that technology flowed between BP and Sohio as a result of foreign direct investment in the United States? Logic would say no, because the technology, if transferred after the acquisition, would have been transferred irrespective of BP's acquisition of Sohio. Under a rigorous application of U.S. governmental definitions, however, it is clear that a transfer of technology was associated with a foreign direct investment, although the investment did not actually cause the transfer of technology.

The Shell Oil-Royal Dutch/Shell case is certainly more ambiguous than the one of BP-Sohio. On one hand, Shell Oil and Royal Dutch/Shell operate somewhat autonomously, and R&D activity at Shell Oil, which is conducted within the United States, is not in any way controlled or dictated by Royal Dutch/Shell. On the other hand, Shell Oil is independently managed, but its existence is a result of an early direct investment by a non-U.S. corporation. There was no clear agreement at the seminar whether or not technology developed by Shell Oil within the United States should be considered as technology transfer resulting from foreign direct investment. Ultimately, of course, the answer to this depends upon the definitions that are accepted.

Trends in Direct Investment

Having established that technology transfer does not play a major role in foreign direct investment in the petrochemical industry, the seminar participants proceeded to address the question of whether or not this pattern was likely to change. In this discussion it was noted that foreign chemical corporations such as ICI in Britain, Badische Anilin und Soda Fabrick (BASF), Farbwerke Hoechst and Bayer A.G. of Germany, Solvay of Belgium, Montedison SPA of Italy, Rhone-Poulenc of France, Sumitomo of Japan, and CIBA-Geigy of Switzerland all were increasingly favoring the direct investment route. Patently, access to the American market and possible exploitation of global-scale economies were the primary motivations for these companies to increase their direct investment activity in the United States, not technology transfer *per se*. However, a firm's use of its technological advantage was acknowledged at the seminar to be a means by which the primary motivation could be strengthened. Thus, some sort of technology transfer into the United States might, in fact, result from

direct investment, even if this had not been entirely intended. Moreover, as demonstrated by the data in the accompanying table, foreign investment in the U.S. petrochemical industry has been a "plus" in terms of creating jobs and boosting GNP.

In order to determine whether a trend could be perceived, several specific cases were examined:

- In the case of BASF's early direct investments in the United States, technology doubtless did play a major role. The Dow Badische Chemical Company, a 50-50 joint venture created by BASF and Dow Chemical in 1959, used BASF technology to manufacture acrylic acid and esters, butanol, and caprolactam. BASF's principal entry into the United States came in 1970, however, with the acquisition of the Wyandotte Chemical Company. This takeover was most likely prompted by access-to-market considerations. Since 1970, BASF has enlarged its Wyandotte subsidiary, constructing several new plants that incorporate BASF's German-developed technology as well as expanding and modernizing older plants. The introduction of new technology into Wyandotte was probably more a means to an end--the expansion of U.S. market share--than strictly an end in itself. Nevertheless, a transfer of technology into the United States did occur.

- Bayer entered the United States in 1955 by forming Mobay Chemicals, a joint venture with Monsanto. Mobay produced urethanes, polyurethanes, and isocyanates, using technology developed by Bayer in Germany. Later, Mobay added polycarbonate production, again using German technology. Mobay's only American competitor in polycarbonates was General Electric. In 1967 Bayer bought out Monsanto's share in Mobay, thus establishing Mobay as a wholly owned subsidiary. As in the case with BASF, the major thrust of Bayer's direct investment in the United States appears to be market penetration. German technology has been used to propel this market penetration, but the technology transfer has been a means to an end, not the end itself.

- The third of the large German chemical companies, Hoechst, seems to have approached direct investment in the United States somewhat more cautiously than BASF or Bayer.[8]

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8. E. Baeumler, A Century of Chemistry (Econ-Verlag, 1968).

Hoechst has a U.S. subsidiary, Hoechst America, which produces textile fibers, dyes, and pharmaceuticals. Hystron Fibers, until recently a joint venture of Hoechst and Hercules Powder Company, but now wholly owned by Hoechst, produces textile filament using technologies developed both in Germany and the United States. Late in 1974, Hoechst acquired Foster Grant, an American producer of styrene, polystyrene, polyamids, other plastics, and a line of consumer sunglasses using these plastics. Again, market and commercial considerations were involved in this direct investment.

• Britain's Imperial Chemical Industries abruptly changed its strategy with respect to the U.S. market in 1971. Prior to that year, ICI had entered the American market largely through licensing, although it held a few small manufacturing operations, primarily serving the textile industry. In 1971, ICI acquired Atlas Chemicals Inc. and began a broad push toward direct participation in the U.S. market. In a recent Chemical Week article, ICI makes clear its intention of using its Atlas base to introduce its own technologies, concentrating on pharmaceuticals, agricultural chemicals, polyester and polypropylene films, dyestuffs, and specialty chemicals.[9]

• Two Dutch companies, Dutch State Mines (DSM) and AKZO, have significant participation in the American market. DSM has two U.S. subsidiaries, Columbia Nitrogen and Nipro, both of which make products using DSM technology. Columbia Nitrogen manufactures urea, a basic agricultural chemical, using DSM's technology, while Nipro makes caprolactam, a basic nylon monomer. Competing technologies exist for both these products in the United States. AKZO has participated in the U.S. market for a long time through two subsidiaries, American Enka and International Salt. These subsidiaries were merged in 1970 to form Akzona, Inc. For many years, American Enka produced rayon, using a Dutch-developed viscose technology, but these operations have recently been shut down. Akzona today is a significant factor in the synthetic fibers industry, using both AKZO and domestically developed technologies. Additionally, in 1971, AKZO acquired Armour Industrial Chemical Company and Armour Industrial Products Company, merging these to form Armak, Inc.

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9. "ICI Finds U.S. Market Its Cup of Tea," Chemical Week, December 24, 1975.

• The large Italian chemical firm, Montedison, has established an American subsidiary, Novamont, to manufacture polypropylene using Montedison's technology. Interestingly, Montedison has been licensing its polypropylene technology to competing American firms at the same time that it has been building grass-roots polypropylene capacity in the United States.

• Petrofina, a large Belgian oil firm, has long participated in the U.S. oil market through its American Petrofina subsidiary. Recently, Petrofina acquired Cosden Oil and Chemical Company, a producer of various basic petrochemicals, including benzene, cyclohexane, styrene, polystyrene, propylene, toluene, and xylene. Petrofina's acquisition most likely was entirely motivated by marketing considerations, as Petrofina already possessed the technology required to produce these products prior to the Cosden acquisition.

• Switzerland's CIBA-Geigy also has operated for a long time in the American market, producing pharmaceuticals, agricultural chemicals, herbicides, and, recently, epoxy resins. CIBA-Geigy uses domestic-developed technology in the United States, but also maintains an active R&D enterprise, the fruits of which are transferred back to the parent company. One seminar participant suggested that as the American operations of other foreign chemical corporations mature, these, too, might come to look like the CIBA-Geigy model.

• Japan's Sumitomo Chemical Corporation has formed a joint venture with Stauffer Chemical Company to produce an insecticide, sumathion, developed by Sumitomo. The production of sumathion will proceed at an existing Stauffer plant but will use Japanese technology.

Looking Ahead: The Policy Implications

Based upon the examination of these cases, the seminar participants were able to agree on a number of points. Unquestionably, the scope of activities by foreign chemical firms in the United States is on the increase. Both the number of foreign companies with direct investments and the total share of the American market accounted for by subsidiaries of foreign firms have grown steadily since the late 1960's. Still, the participants noted that technology transfer was a minor factor behind this growth. Few, if any,

foreign firms come to the United States with the specific objective of gaining access to American technology, because access is already open to them through licensing. There may be exceptions to this, but such exceptions are small in number and account for very little of the total of foreign direct investment in the United States.

Entry into the U.S. petrochemical market is no easy matter, even for a large, established foreign firm. In order to gain or build a share of the market quickly, foreign enterprises often acquire ongoing American operations, usually small or medium-sized firms such as Atlas or Wyandotte. Sometimes, after acquisition, the foreign parent introduces to the subsidiary new technology developed abroad. The best explanation for this is probably that the foreign company wants to put its "trump card" forward in an effort to make a decisive entry into the United States. An alternative explanation suggested at the seminar is that the foreign firm introduces its new technology as soon as possible in order to advance along the learning curve and possibly also to achieve maximum global economies of scale.

When a foreign company enters the United States via a grass-roots investment, as is the case with Montedison, or a joint venture such as Sumitomo, there is a tendency for it to use its best new technology. The reason for this is probably identical to the motive for a foreign firm to introduce new technology to an acquired subsidiary--namely, that it can compete better with new technology.

The impact of direct investment from abroad on the petrochemical industry in the United States is reflected in Table 2 (see page 62). This shows the proportion of U.S. capacity that foreign companies hold in the production of certain heavy industrial chemicals and resins, which constitute a large volume of the total output of petrochemicals. The effects of foreign direct investment in the U.S. petrochemical and chemical industry upon America's overall interests are favorable, on balance. This judgment may be weighted by the experience of the seminar participants who mainly represented U.S. companies, not foreign corporations or American subsidiaries of foreign corporations. The presence of foreign firms, the participants stated, makes the U.S. industry more competitive, especially given the input of foreign technology. Asked whether or not the apparent trend of foreign firms exploiting their domestically developed technology directly in the American market

by way of direct investments, rather than by licensing, has lessened the availability of this technology to U.S. firms, the participants claimed it had not. The participants expected that foreign-developed technologies would continue to be licensed to American firms, even though such innovations might also be introduced directly into the United States via foreign-owned subsidiaries.

Moreover, as the participants emphasized, direct investment is a "two-way street," and, as such, it provides benefits and opportunities in both directions. Finally, the participants agreed that any attempt to impose controls over foreign direct investment in the petrochemical industry would very likely result in retaliatory restrictions abroad.

Table 2 U.S. Petrochemicals: Impact of Foreign Technology Transfer

Major 1st Line Petrochemical Derivative(a)	Companies Operating in the United States		Foreign Controlled Capacity										
				Shell(d)			BASF			Other			
	1975 Capacity (Mil.lbs.)	Number of Firms	Share of U.S. Capacity	Capacity (Mil.lbs.)	Technology	Technology Exported	Capacity (Mil.lbs.)	Technology	Technology Exported	Company	Capacity (Mil.lbs.)	Technology	Technology Exported
Low Density Polyethylene	6,715	17	-	-	-	-	-	-	-	-	-	-	-
High Density Polyethylene	3,150	12	13%	-	-	-	-	-	-	Soltex (Solvay)	400	U.S.(c)	No
Ethylene Oxide	5,070	12	12%	300	Part. U.S.	Yes	285	U.S.(c)	No	-	-	-	-
Ethyl Benzene	8,510	15	11%	-	-	-	-	-	-	Foster Grant (American Hoechst)	970	U.S.(c)	No
Ethyl Dichloride	13,575	11	25%	3,360	?	Yes	-	-	-	-	-	-	-
Ethanol	2,067	5	14%	272	U.S.	Yes	-	-	-	-	-	-	-
Acetaldehyde	1,400	4	-	-	-	-	-	-	-	-	-	-	-
Polypropylene	3,000	12	15%	280	?	No	-	-	-	Novamont (Montecatini)	160	Foreign	No
Propylene Oxide	2,313	5	8%	-	-	-	175	U.S.(c)	No	-	-	-	-
Isopropanol	2,275	3	35%	800	U.S.	No	-	-	-	-	-	-	-
Acrylonitrile	1,660	4	-	-	-	-	-	-	-	-	-	-	-
Cumene	3,735	14	-	-	-	-	-	-	-	-	-	-	-
OXO Alcohols(b)	1,500	6	23%	240	U.S.	Yes	200(f)	Foreign	No	-	-	-	-
Caprolactam	800	3	50%	-	-	-	200(f)	Foreign	No	Nipro (DSM)	200	Foreign	No
TOTAL	56,770		14%	5,252 (9.2%)			860 (1.5%)				1,730 (3%)		

(a) The first 13 derivatives account for 90% of total downstream utilization of Ethylene and Propylene.
(b) C4's only. (c) Acquired via purchase. (d) 100% owned by Shell Oil, in turn owned 69% by Royal Dutch Shell.
(e) Dow-Badische a 50:50 joint venture.

CONCLUSIONS

The most important conclusion reached in these seminars is that foreign direct investment has not led to significant net technology outflow in the four sectors of U.S. industry that were examined. Very few instances were identified in which foreign direct investment resulted in any appreciable net outflow of technology. If such investment did yield a technology outflow, it had been expected that this would be observed in the industries selected for examination. The participants in these seminars believe that no important cases of direct investment leading to technology transfer were omitted.

In the four industries examined, foreign direct investment is not a major route by which technology flows out of the United States. More important routes of outflow include: licensing and selling technology, diligence in following the open scientific and engineering literature and attending technical meetings, "reverse engineering" performed on the products of other companies, and the so-called "brain drain" or the mobility of technical personnel. Foreign direct investments are apparently made primarily for commercial reasons, particularly the desire to gain access to a thriving U.S. market; they are seldom made the objective of gaining access to American technology *per se*.

Several other conclusions were reached in the seminars:

- A net inward flow is a much more prevalent form of technology transfer resulting from foreign direct investment. This occurs because a foreign company believes it has a superior technology (involving a new product, application, or process) that will allow it to compete successfully against established--though presumably inferior--technologies in the American market. Often these cases involve the acquisition or establishment of manufacturing and, perhaps, R&D facilities in the United States, sometimes via a joint venture with an American company. There are many examples of this, particularly in the petrochemical, electronics, and non-electrical manufacturing industries.

- Some cases are sufficiently complex, with technology flows going in different directions and changing over time, that they defy a more precise determination of the balance between inward and outward flows. There are many cases of

foreign investment in which no significant technology appears to flow in either direction. In such cases the primary purpose of the investment is often (again) to gain access to, and knowledge of, the American market. This is frequently accomplished by establishing or acquiring manufacturing facilities in the United States, but sometimes R&D facilities are also involved. In the latter circumstance, investment may eventually lead to new technology. To some extent, this new technology will flow out of the United States, but it will also add to the internal technology stock, since it wasn't there before the investment.

- Multinational companies, both U.S.-based and foreign-based, are proving to be an important source of technology flow in both directions. The net balance depends very much on the particular company. The primary R&D may be conducted outside the United States, as is often the case with a foreign-based multinational, and in this event the inward technology flow exceeds the outward flow. Multinational pharmaceutical research done by most of the large companies in this industry, both U.S. and foreign, is fully multinational--that is, some of the R&D is done in the United States, while other, complementary parts are done abroad. Thus, the final development of a new product or process results from the flow of information back and forth between the firm's laboratories here and abroad, as neither the U.S. laboratory nor the foreign laboratory is entirely responsible for the development.

- Representatives of each of the four industries held essentially unanimous views that the free flow of technology provides a positive technology benefit to the United States, and any actions that might reduce the flow, such as placing restrictions on foreign direct investment, would only serve to hamper America's technological innovation.

- Finally, in response to the question concerning what current trends might hold for the future, the seminar participants agreed that there seems little prospect of major changes in the present situation--i.e. foreign direct investment being driven much more by market considerations than by a desire to acquire American technology. Since this most often results in an inflow of technology rather than in an outflow, a reversal of this net inward flow was not expected by the participants. Science and technology are international, and other nations, especially Japan and Germany, are becoming increasingly skilled.

The participants believe that the future is likely to bring an even greater inflow of technology to the United States as foreign investors bring to bear an impressively sophisticated technology to gain entry to America's domestic markets.

TECHNOLOGY TRANSFER FROM

FOREIGN DIRECT INVESTMENT IN THE UNITED STATES

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