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TRADE-OFFS IN INTERNATIONAL FLOWS OF SCIENTIFIC AND TECHNOLOGICAL INFORMATION

Submitted

to the

Technical Advisory Board
United States Department of Commerce

by

VLADIMIR SLAMECKA

Chairman, CTAB Working Subgroup
on
ional Scientific and Technical Information Issues

hool of Information and Computer Science
Georgia Institute of Technology
Atlanta, Georgia 30332

September 1980

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ABSTRACT

The report examines the nature of the trade-offs involved in the international flows of non-military scientific and technological information, both public and proprietary. The trade-offs include economic variables, social and cultural variables, and reciprocity in the exchange of information. Recommendations are offered for increasing U.S. returns from scientific and technological information and for strengthening the U.S. information service sector. The Appendix of the study identifies and briefly discusses a number of mechanisms capable of managing and, partly, regulating the international flows of scientific and technological information. The study is motivated by a desire to facilitate world trade and improve the competitive role of the United States.

TABLE OF CONTENTS

	Page
ABSTRACT	ii
I. INTRODUCTION	1
II. BENEFITS AND TRADE-OFFS OF INTERNATIONAL INFORMATION EXCHANGE	4
A. Economic Variables	4
1. Foreign R & D Capability	4
2. Competitiveness of Foreign Economies	7
3. U.S. Information Services and Foreign Markets	9
B. Social and Cultural Factors	11
1. Information and Cultural Development	11
2. Information and Socioeconomic Development	14
3. Freedom and the Flow of Information	20
4. Information and Diplomacy	23
C. Reciprocity in International Information Exchange	25
1. Foreign Fast-Diffusing Information: National Policies	26
2. Availability of Foreign Fast-Diffusing Information in the United States	29
3. Foreign Slow-Diffusing Information	31
D. Conclusions	34
III. RECOMMENDATIONS	39
A. Increasing U.S. Returns from Scientific and Technological Information	40
B. Strengthening the U.S. Information Service Sector	46
TABLES 1-13	51-64
FIGURES 1-6	65-70
APPENDIX: INTERNATIONAL INFORMATION FLOWS: SELECTED CONTROL MECHANISMS	71
1. Direct Investment in Foreign Manufacturing Subsidiaries	71
2. U.S. Foreign Sales of High Technology Goods	73
3. International License Trade	74
4. Tax Policies	75
5. Foreign Government Action	76
6. Applications of Information Technology	78
7. Intellectual Property Rights	80

LIST OF TABLES

Page

1. R&D Expenditures as a Percent of GNP, Selected Countries, 1961-1977 51

2. Resources Devoted to Industrial R&D in OECD Countries in 1975 (or Nearest Year) 52

3. Macro-Data: GNP (Current Prices) 53

4. Balance of Trade in Current Prices 54

5. Industrial Production Growth in Developing Countries, 1971-1977 . 55

6. Balance of Payments Summary for Developing Countries, 1971-1977 . 56

7. Rate of Productivity Growth, 1960-1979. 58

8. Foreign Manufacturing Subsidiaries Established by 180 Multinational Enterprises, by Principal Activity 59

9. Foreign Manufacturing Subsidiaries Withdrawn by 180 Multinational Enterprises, by Principal Activity 60

10. World Book Production (1976) 61

11. World Production of Scientific and Technical Periodicals (1960-1980) 62

12. World Production of Patents (1974) 63

13. World Abstracting and Indexing Organizations, 1960-1975 64

LIST OF FIGURES

Page

1. R&D Expenditures as Percent of GNP 65

2. Scientists and Engineers Engaged in R&D per 10,000, 1963-1973 . . . 66

3. Number of Nobel Prize Awards for U.S.; U.K.; West Germany: Japan 67

4. Major Technical Innovations for U.S., U.K., Japan, West Germany per Three-Year Periods (1953-1973) 68

5. U.S. Share of World Exports of Manufactured Goods, 1958-77, in Percent 69

6. Output Per Hour in Manufacturing (Increase in Percent, 1950-77) . . 70

I. INTRODUCTION

Communication, according to a recent United Nations study,[1] has reached a planetary dimension as a result of the conjunction of four processes: spectacular expansion of conventional channels and means of communication; scientific and technological innovations -- more particularly, invention of new technological devices for transmission of messages; opening up of larger markets for information goods and services; and a trend toward uniformity and standardization of information products.

The streams of messages that constitute the contents of planetary communication are of several characteristic types, all generically referred to as "information." In operational terms one can distinguish among four major categories of information: 1) personal information, the frequently private messages from, to, and about individuals; 2) organizational information, comprising internal messages generated by governments, corporations, agencies and other legal bodies, and pertaining to their conduct of operations and plans; 3) news and entertainment information, the messages collected and distributed by mass communication media for consumption by the public at large; and 4) scientific and technological information, a conglomerate of purposive messages pertaining to "technical" problem solving and decision making in virtually all levels of society. Questions concerning the generation, quality, ownership, control, availability, and distribution, and means of transmission of all these categories of information have become one of the more important and contentious central subjects on the agenda of international discussions,[2] and many countries are consequently preoccupied with attempts to formulate national information policies that would guide them in these discussions.[3]

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[1] International Commission for the Study of Communication Problems. Interim Report on Communication Problems of Modern Society. Paris, UNESCO, 1978.

[2] See, for example, Turn, R., ed., Transborder Data Flows: Concerns in Privacy, Protection and Free Flow of Information. Arlington, Va., AFIPS, 1979. 2 vols.

[3] See, for example, Bushkin, A.A. and Yurow, J.H., The Foundations of United States Information Policy. Washington, D.C., U.S. Department of Commerce, June 1980 (NTIA-80-8).

This study concerns the last category of information referred to above. In the most general sense, scientific and technological information connotes the sum of purposive knowledge and even wisdom of man -- the record and interpretations of his observations, activities, experiences and speculations accumulated over millenia; for this reason it has been termed a "national resource, as useful in its own way as any other national resource, material or intellectual."[4] The resource exists in the form of and is communicated by means of signs and symbols that, when perceived, are said to convey information. Depending on the manner in which signs and symbols are encoded we may distinguish three principal carriers of information: 1) verbally encoded information, as in records and publications of various kinds; 2) information encoded in physical devices, the output of technology; and 3) society encoded information, being the knowledge and experiential know-how possessed by human experts and their organizations. Of the numerous uses of information, two that are particularly related to this study are use in the production of knowledge, and use in the production of goods. The former endeavor is typically called science, the latter industry; and accordingly it is sometimes useful to distinguish between "scientific" and "technological" information.

Present-day issues in the international exchange of scientific and technological information have numerous facets, and some of these are already being dealt with in the United States.[5] This study approaches the subject largely within an economic context, for two major reasons. First, it is becoming clear that the contentious issues regarding international information transfer are basically economic in nature, having as their common denominator the perception of value of information as an individual,

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[4] Mews, H. "Responsibility for the Development of Scientific Information as a National Resource," Proceedings of the International Conference on Scientific Information. Washington, D.C., National Academy of Sciences, 1959.

[5] See bibliography in: U.S. Senate. Committee on Labor and Human Resources. International Information Exchange: Relevant Activities of the White House Conference on Library and Information Services. Washington, D.C., U.S. Government Printing Office, June 1980. Pp. 148-150.

corporate and national resource. The second reason is related to the United States's desire to facilitate world trade and to improve this country's competitive role in it. We are challenged in international markets primarily as a producer of goods (although increasingly also as a producer and vendor of information), and basic to our future is our ability to innovate in, and increase the productivity of, the industrial sector. While there is evidence that the U.S. labor force may be in a transition to an information society,[6] the transition is unlikely to be successful without a rather dramatic improvement of our capability to produce goods in the competitive world economy. A successful "information economy" is predicated on a successful production economy.

In conformity with this context and motivation, the objective of this study is to examine the nature of benefits and detriments that arise as a result of international flows of civilian (non-military) scientific and technological information. These trade-offs, as described in the following chapter, fall into three categories: economic variables, social and cultural variables, and reciprocity in the exchange of knowledge. A summary of the analysis leads to a number of recommendations aimed at improving the U.S. position in this area; these are offered in Chapter III. The Appendix of this report discusses a variety of mechanisms that affect the intensity of international flows of scientific and technological information; it is hoped that this discussion will be of interest to agencies and individuals responsible for the formulation of U.S. national policies in this vital field.

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[6] Rubin, M.R. "The Role of Information Goods and Services in the U.S. Economy," Information Processing and Management. (In press)

II. BENEFITS AND TRADE-OFFS OF INTERNATIONAL INFORMATION EXCHANGE

The intent of this chapter is to identify and, when possible, indicate the extent of major benefits and disadvantages that accrue to the U.S. from engaging in international exchange of scientific and technological information. Since most effects are not measurable in absolute terms, and since the value of benefits or disadvantages may vary with circumstances, the notion of "trade-off" is not one that is clearly specifiable. The utility of this chapter thus lies primarily in its attempted elucidation of the variables of the equation rather than in its attribution of value to each variable.

The effects are loosely grouped in three groups: economic variables, sociocultural variables, and reciprocity in information flows.

A. Economic Variables

The introduction has suggested that international information transfer has become an important, and sometimes contentious, issue because its essence is economic. International information flows affect various elements of the economic domain in complex ways that are difficult to isolate and quantify. This section describes and, when possible, discusses the relationship to information flows of aspects of three economic phenomena: the growth of foreign research and development (R & D) capability, the competitiveness of foreign economies, and the foreign markets for U.S. information services and products.

1. Foreign R & D Capability

Without question, international collaboration in scientific R & D has been important in a great number of inventions, innovations, and product developments as it has been to the viability of science as a social enterprise. The questions that loom large are the effect of this collaboration on the development of indigenous national R & D capabilities and the role of information sharing and transfer in this process. The latter is not easily determined; however, as a start we may wish to compare the trends of the U.S. and some foreign R & D enterprises in terms of expenditures, fraction of population engaged in R & D, and several other indicators of national R & D capabilities.

Most available studies concentrate on trends in expenditures. Figure 1 and Table 1, for example, show R & D expenditures as a percentage of Gross National Product for the U.S., U.S.S.R., U.K., France, Federal Republic of Germany, and Japan. Over the past twelve years, U.S. expenditures for R & D have declined as a share of the GNP. There has been an increase in the proportion of resources devoted to R & D for Japan and the Federal Republic of Germany, this country's major industrial competitors. Moreover, the rapid growth of the GNP in these two countries increases the importance of their greater effort on research and development.[7] Table 2 shows that the U.S. has fallen way behind West Germany and Japan in proportion of resources invested in non-defense R&D. (Capability, however, does not necessarily correlate with expenditure, if differences prevail in the efficiency of the R & D process in the various countries.) Evidence has been presented in the case of drugs, for example, that indicates higher development cost and time expenditures in the U.S. than overseas, on the average.[8] OECD describes trends in industrial R & D in eleven major countries of the Organization.[9]

Another measure of the intensity of a nation's R & D effort is the fraction of population so engaged. Figure 2 shows the number of R & D scientists and engineers per 10,000 population. That number has been declining in the U.S. since 1969, while increasing in the Federal Republic of Germany, Japan and the U.S.S.R.

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[7] See also Section D (Conclusions) on the relationship between R & D and productivity.

[8] Technology, Trade and the U.S. Economy. Washington, D.C., National Research Council, 1978.

[9] Trends in Industrial R&D 1967-1975. Paris, OECD, 1979.

Other measures of the relative national R & D capabilities include: number of Nobel Prize awards (Figure 3), and number of major technical innovations (Figure 4). Table 2 shows that, of the OECD countries in 1975, the United States contributed 43.3 percent of the total manpower and 49.8 percent of the total expenditures. Other useful indicators would be the number of patents issued and the number of papers published per country.

Indicative of the research support in high technology industrial development are the following examples:[10]

- In the U.K., the National Enterprise Board (NEB) allocated $200 million to a program to develop capability in integrated circuit design in LSI and VLSI; $46.5 million was used to start INMOS, a research firm in Colorado Springs, which is intended to transfer technical information to British firms.

- The French government has spent $53 million (U.S.) since early 1978 to stimulatethe French electronics industry. The 1977 "Plan Composants," allocated $133 million over a 5-year period for a program to develop French IC capacity. The first $44 million was split between RTC (La Radiotechnique Compiloc, the Philips/France branch) and Thomson-CSF (a French firm). It enables Thomson to develop bipolar technology and MSI linear products. It enables RTC to develop LSI TTL and ECL devices. In 1978, the Plan has given $44 million to a Motorola (U.S.)-Thomas-EFCIS (joint venture between Thomson and the French Atomic Energy Commission) combination within which Motorola will give MOS technology to the French. The final $44 million was given to National Semiconductor (U.S.) and Saint-Gobain-Pont-a-Mousson for an NMOS and C-MOS plant.

- Japan's efforts, especially those of MITI, at encouraging technical information transfer are well known.

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[10] Scace, R.I., VLSI in Other Countries. Lecture notes for a short course at American University, June 1979.

2. Competitiveness of Foreign Economies

The purpose of this section is to address the question of the competitiveness of economies as a result of the use of scientific and technological information generated either in the U.S. or by U.S.-based firms. "Competitiveness of foreign economies" means how well foreign businesses compete for sales and for scarce inputs (like trained professionals) with other firms in the world, especially in the United States.[11] Concern over foreign competitiveness does not, however, imply that international competition is unhealthy or undesirable: often the benefits from the economic growth of foreign economies are mutal, as is mutual interest in progress.

The notion of competitiveness of foreign economies probably also entails three other conditions. First, as an entire economy becomes "more competitive," we would expect it to be developing an infrastructure -- a native supplier industry. (In what is now a well-known notion, we would expect the economy to be capable of producing more of its high technology consumption goods and/or inputs to its industry -- that is, to substitute for imports. We might also expect that the country would begin importing some items it had previously made itself. This phenomenon is also consistent with product life cycle explanations of shifting patterns of international trade. Of course, as native firms compete more effectively with U.S.-based firms, the U.S. firms might also establish more intensive marketing efforts in an area.) Second, higher technology firms might comprise a larger proportion of native enterprises. Third, the term refers primarily to sectors of an economy which participate in an international market.

Measuring an economy's competitiveness objectively is an impossibility, although there are a number of indicators of an economy's competitivenss which -- if interpreted with care -- can be helpful.

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[11] We should note that "competitiveness" in this phrase does not mean that an economy becomes more like the proverbial perfectly competitive industry of which economists and antitrust lawyers speak. Rather, it suggests that new industries in the country increase the amount of competition in the international market. The industries themselves may well be oligopolistic.

Tables 3 and 4 present some macro information about several important industrialized countries. Tables 5 and 6 indicate similar statistics for developing nations. It is clear that the United States no longer dominates the world economy as it did just after World War II: our GNP, per capita income and trade balance are not as superior as they once were. Since these figures are in constant native currencies, it is wrong to compare the raw figures: rates of exchange and inflation have differed among the countries. Even without these corrections, however, Table 3 points out that the U.S. GNP no longer dwarfs that of other industrial nations. Table 4, with balance of trade figures in U.S. current dollars, shows how the U.S. balance of trade figures have changed in the postwar period. Crude oil has had a great deal to do with this, and the figures can be adjusted for crude purchases, and for inflation. Even so, the picture remains very much the same: the U.S. is no longer the predominant exporter in the developed world; export volumes have increased in most countries.

There are other indicators of increased competitiveness of foreing economies. Figure 5 shows a decline between 1958 and 1977 of over 30 percent in the U.S. share of world exports of manufactured goods; given the resurrection of the industries of Western Europe and Japan during these two decades, the percentage of U.S. decline in the proportion of world manufacturing is probably larger. Figure 6 (Increase in Output Per Hour of Manufacturing) shows that Japan, West Germany, France and the United Kingdom all exceeded the United States in the period 1950-1977. Finally, Table 7 shows the rates of productivity in a number of industrialized countries for the period 1960-1979.

A very important and effective means of transferring technology internationally is the wholly-owned manufacturing subsidiaries established in foreign countries. Of course, subsidiaries do not all transfer technical information to nationals of their host countries to the same extent. Subsidiaries of U.S. firms also neither repatriate the same percentages of their profits nor invest identically. Nevertheless, some statistics on the extent of U.S. firms' subsidiary activities is indicative of the use of U.S.-developed information in foreign countries. We might speculate that it is precisely to exploit slow-diffusing technological information that U.S. firms establish foreign subsidiaries. Tables 8 and 9 provide indicative data relating to the establishment and closing of U.S. manufacturing subsidiaries in foreign countries prior to 1975.

These indicators and examples lead many writers to conclude that since World War II foreign economies have grown strong relative to the U.S. However, there is only a tenuous connection between these phenomena and whatever is meant by an economy's "strength." The question that is important to this study is the connection between the strength of a national economy and the inflow and outflow of scientific and technological knowledge. To our awareness, such effects have not been assessed for the U.S. or other economies. (In the Appendix to this study, we examine some mechanisms through which U.S. scientific and technological information might affect an economy's strength.)

3. U.S. Information Services and Foreign Markets

The past decade has witnessed a growth of a variety of information services in both the public and private sectors. These services are a component of the "informaton industry," a dynamic segment of the U.S. economy.

The phrase "information services" is usually taken to encompass information transmission, information processing, and scientific/technological information services. The last consists of two categories: a) information supply services -- publishers, database vendors and document suppliers -- who issue large amounts of numeric and non-numeric data and collect and organize it into massive, dynamic compilations in printed and/or electronic form, and make these available to clients for information searching and retrieval in a variety of modes. Because of the large investment and the large markets required by these services, they tend to be oligopolistic; and b) information analysis services concerned with the interpretation, reformulation and synthesis of data and information. Their products answer specific needs, often cater to limited markets, and are relatively costly because of their highly labor-intensive nature which requires advanced skills. With the exception of relatively few large consulting and software houses, this disaggregated group consists of small firms and consultants.

The size of the STI services is estimated at 1200 organizations; 20-25% of these are affiliated in the Information Industry Association (IIA). Based on the $1.5 billion annual sales of its members, IIA estimates the STI service sector to account for about $6 billion of sales per year. This makes this sector slightly smaller than the information processing services which are estimated by the Association of Data Processing Service Organizations (ADAPSO) to have an annual turnover of $7.5 million.

Data on the volume of international sales by the STI services of the United States are currently being compiled by the IIA; the survey[12] embraces 800 of the total population of 1200 organizations. If one applies the 25% figure that ADAPSO believes to account for income from international sales of information processing services, the corresponding annual figure for the STI service sector is $1.5 billion per year. This is not unreasonable considering that total U.S. exports of all kinds of information services in 1978 were $8.6 billion.[13] Assuming that these estimates are reasonably accurate, the STI service sector thus accounted (in 1978) for less than 1% of total U.S. exports, about 7% of total exports of U.S. services, and about 17% of exports of all U.S. information services.

Speculating about the magnitude of future global markets for information services demands prudence. Whereas the vast majority of mankind does live in countries as yet unaffected by information services, only a thin stratum of their peoples can be viewed as potential users of scientific and technological information services (in contrast to cultural and entertrainment services) in the next decade. We should thus expect the market growth to be initially evolutionary, accelerating at a rate commensurate with the increase of the global "absorptivity index" for this kind of information.

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[12] Information Industry Association. <u>The Business of Information Report 1980</u>. (To appear)

[13] Rubin, M.R., <u>Op. cit</u>.

B. Social and Cultural Factors

1. Information and Cultural Development

The interplay between culture and communication is very intimate. "It may be wondered whether, in the final analysis, culture and communication are not one and the same thing, whether culture is not the message of which communication is the medium," writes the McBride Commission. Whatever their relationship, the cultural impact, content and message of communication are of such crucial importance that communication as a whole becomes one of the main vehicles of cultural development."[14]

A relevant aspect of increasing importance in the cultural effects of international flows of scientific and technological information is the broadening scope of this resource.[15] Its traditional form, from the 19th century on, has been discipline-based, as a result of which the resource has served primarily a relatively narrow social group -- that of scientists and researchers. The second era, starting with World War II, was characterized by "big science" and technology serving mission-oriented objectives having strong engineering and application emphasis. The most recent phase started in the late 1960's, emphasizing information for solving socio-technical system problems: providing better housing and transportation, improving the quality of life in cities, equalizing job opportunities, preserving the environment, and similar benefits. As a result of this evolution, scientific and technological information is intended to and does reach increasingly broader strata of the population -- not only scientists but technologists, developers, managers, entrepreneurs, policy-makers and educators -- problem-solvers in all walks of purposive activities.

The extending scope of scientific and technological information has other characteristics. Whereas the motivation of discipline-based

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[14] International Commission for the Study of Communication Problems, Op. Cit., p. 52.

[15] Cf. Guiliano, V., et al. Passing the Threshold into the Information Age . . . . Boston, Mass., A.D. Little, 1978. 2 vols.

information has been primarily the growth of objective knowledge, the present-day information resource contains increasingly strong value judgments. These have the ability to foster a culture based on a plurality of views and the increasing spread of knowledge. Conversely, this characteristic of the present-day information resource leads increasingly to contentions that it does not consist of and transmit neutral messages. In an oft-quoted study, the French suggest that "leaving to others . . . the responsibility for organizing the 'collective memory,' while being content to dig into it, is equivalent to accepting cultural alienation."[16]

The doubtful validity of such dramatic claims notwithstanding, the assimilation and use of new scientific and technological information can exert an impact on a nation's culture. Consider the different emphases attributed to, respectively, military industry information and consumer-product industry information. One example is the Soviet Union which, while aggressively acquiring military information from the Western World, is withholding consumer-product information from its populace. The emphasis on the military has shaped the Soviet nation to be a closed, secret, and controlled society. Japan is the example of a nation that has aggressively acquired and applied consumer-product information. Their lack of raw materials and their island existence have shapped and been shaped by the emphasis on industrial technology obtained in an open and competitive manner.

In another contrast, the suspension of acquisition of organized knowledge by China in 1966 led to a 10-year hiatus during which colleges and universities were closed. The culture shock that followed was as disastrous for their society as it was for their economy: a whole generation was lost.

The world is more and more one where barriers to people flow, materials flow, and ideas flow are diminishing. As all kinds of information

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[16] Nora, S. and Minc, A., L'informatisation de la Societe. Paris, Editions du Seuil, 1978. P. 49.

flow more freely, national cultures will attempt to benefit from it but will also have to struggle if they are to maintain their individualities in the process, by preserving their geographical boundaries, national languages, monies, laws, and traditions. Kahn writes: "It seems quite likely that outside the 20% of the world that is expected to live in postindustrial societies by the year 2000, the other 80% of humanity is likely to be deeply preoccupied with various kinds of reactions that resulted from the process of more or less forced Westernization."[17] That "these kinds of reactions" are anything but trivial is amply illustrated in Iran; yet it is difficult to see how countries that close their borders to science and technology can attain a higher standard of living for their peoples. De Sola Pool has noted a "fairly strong correlation between the inflow of information from abroad and national development.[18]

A specific example of the flow of scientific information impacting on a culture is that of national language. Printed information is more and more being distributed by computer, which forces a standardization on English as the language to be used. Evidence is available of a trend toward English as an international language in chemistry,[19] and a similar trend holds for the national physics research journals and reports; Japan, Poland, and the Federal Republic of Germany, to cite only three, have gone increasingly to the English language in such sciences. More than 50% of the world's published literature in science is in English. Concerned with this trend, smaller countries are pressing for national programs to force scientific publishing in vernacular languages. The proliferation of new "official" languages in many recently-born countries cannot but retard their economic development, many observers fear.

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[17] Kahn, H., "The Emergent United States . . . Post-Industrial Society." In: U.S. House of Representatives, The Management of Information and Knowledge. Washington, D.C., Government Printing Office, 1970. P. 24.

[18] Pool, I. de S., "The Communications Revolution in an Interdependent World." Presented at the 43rd Annual Meeting of U.S. National Commission for Unesco, Athens, Ga., December 12-15, 1979.

[19] Garfield., et al., "The Synthetic Chemical Literature from 1960 to 1969," Nature 242:307-309 (March 1973).

In general, scientific and technological information (in contrast to mass media and entertrainment) is probably the least likely category of knowledge to cause cultural domination. Culturally, intensive and unhindered flows of this information should cause broader participation of peoples in social development; greater awareness of reality; a balanced, pluralistic interaction in the cultural field, with attendant democratization; and an awareness of a common destiy in the development of a global society.

2. Information and Socioeconomic Development

Few themes stand out in the literature on national socioeconomic development of poor countries more sharply than the belief that "information is indispensable to development." The theme is reiterated in documents emanating from both developing countries and international organizations such as the United Nations. A measure of importance attached to the essential relationship between information and development is indicated by the fact that 20% of the 190 consolidated recommendations prepared for the 1979 U.N. Conference on Science and Technology for Development dealt with some aspect of information. The recommendations of the conference itself also reflect this emphasis.[20]

Probably the most important reason that motivates developing countries to presage for scientific and technological information is their desire to have access to the technology of industrialized countries. "Access to technology" connotes three major issues. First is the misgivings over proprietary knowledge: developing countries are given to the suspicion that the international system of patents, licenses and trademarks is a tool of the industrial countries designed to prevent less advanced peoples from obtaining the resources and knowledge necessary for advancement, lest

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[20] Saracevic, T. "Perception of the Needs for Scientific and Technical Information in Less Developed Countries." In: V. Slamecka, ed., Scientific and Technical Information Services for Socioeconomic Development. Washington, D.C., International Science and Technology Institute, April 1979.

they create competition for their producers in the international markets. Industrialized countries, on the other hand, see the existing system as working reasonably well to provide technology transfer to developing countries, and as an essential safeguard to promote innovation and assure reasonable returns of investment for research and development. The general U.S. strategy has been to debate the issue of proprietary technology at the platform of the World Intellectual Property Organization (WIPO).

The second issue usually embodied in the question of access to advanced technology is international control of multinational corporations which control the large majority of the technology transferred to the developing world. Here it is contended that multinationals are exploitative and foster technological dependency rather than contribute to socioeconomic development; the answer is seen in stricter control and regulation of the multinationals by developing countries and international organizations. While agreeing in principle to the necessity for certain codes of conduct for multinationals, the developed countries argue that over-regulation would yield an infertile ground for investment and prevent technology transfer rather than encourage it. U.S. strategy has been to confine discussions of this issue to the "Code of Conduct" negotiations at UNCTAD.

The third issue is the desire and need of developing countries to share benefits of the resources of science and technology in industrial countries, including a whole range of information resources and the technical training and education required for understanding and utilizing modern technology. These resources are said to be a common heritage of mankind and they can, at least in theory, be used by anyone. The preoccupation of developing countries with access to this resource repeatedly refers to the many obstacles, including cost, that prevent them from finding what technologies are available (including those available under the existing patent and licensing system), how appropriate the technologies are to their needs, and how they can afford them.

There is a general consensus in the industrial world that developing countries must not, and cannot, be denied access to the body of scientific and technological information residing in the industrialized world. In attempting to facilitate such access, however, two major sets of problems need to be overcome. The first of these is a pragmatic one: for a variety of reasons such access as is now available to this information is less than straightforward, due to numerous causes having to do with language, idiosyncratic forms of information organization, pricing conventions, currency exchange, communications facilities, and with a lack of awareness of the sources of such information. Whereas developing countries are generally aware where in the world the majority of scientific and technical information resides, their awareness of specific resources is extremely poor. Their own collections of published literature are meager, and they perceive organizational frustrations, delays and economic difficulties in attempting to obtain access to and copies of foreign literature.

The second set of problems is conceptual in nature, and its cause is the absence of adequate understanding of the relationship and interplay between information and development. In 1954, Sir Arthur Lewis offered a pioneering discussion of the general role of knowledge in socioeconomic development, and suggested that accumulation of knowledge is one of three indispensable elements for the development process to occur, along with the accumulation of capital and the "effort to economize."[21] There is, however, almost a complete absence of scientific studies of the behavior, needs and other characteristics of problem solving information users in developing countries, and the literature reveals almost no hard data documenting the complex interplay between knowledge and development in technologically less advanced countries. Thus while the importance and the role of information in development are taken for granted, developing countries have been less than fully able to determine what information they need and, more importantly, what is the nature of the information support services optimal to their problem solvers.

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[21] Lewis, A.W. Theory of Economic Growth. London, Allen and Unwin, 1954.

The United States response to developing countries regarding scientific and technological information has been generally sympathetic but indecisive. Nearly ten years ago, responding to a request from the Agency for International Development, the National Academy of Sciences addressed the topic and made a number of recommendations directed toward enhancing the transfer of scientific and technical information to developing countries, developing and strengthening the information infrastructure of these countries, and improving access to U.S. information resources.[22] In conformity with the understanding of this issue that prevailed at that time, these recommendations did not account for some of the most salient but subtle factors underlying this problem.

The following is a brief review of current U.S. activities in the information field relating to developing countries. It has been estimated[23] that the U.S. government spends today over 15 million dollars annually on a variety of STI services specifically targeted to developing countries, most of it through AID supported projects. This approximate figure includes support of formal information systems (bibliographic and factual data bases with their publication and dissemination services), as well as specific kinds of technical assistance which improve scientific and technical information handling skills at the local level. The major AID supported activities are the collection of its own and contractors' research reports and project experience descriptions, support to the National Technical Information Service (NTIS) of the Department of Commerce, support of various bibliographic data collection activities (such as the population information program at Johns Hopkins University), support of literature clearinghouses, and information brokerage services (through contractor organizations such as the Central American Technological Research Institution, the Georgia Institute of Technology, Denver Research Institute, the

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[22] National Academy of Sciences. Board on Science and Technology in Development. Scientific and Technical Information for Developing Countries. Washington, D.C., National Academy of Sciences, April 1972.

[23] Proposal for a New Service To Be Offered by AID to Improve LDC Access to U.S. Science and Technology. Prepared by AID Office of Development Information and Utilization, in cooperation with the Office of the U.S. Coordinator for the U.N. Conference on Science and Technology. Third Draft, August 6, 1979.

Volunteers in Technical Asistance, the International Executive Service Corps), and ad hoc information oriented technical assistance in specific developing countries. The most significant recent project funded by AID (through the National Science Foundation) is a multi-year contract to design national STI services in Egypt.

Other U.S. government activities relevant to development needs are underwritten by the Department of Commerce which, through its Trade Opportunities Program, will refer requests from developing countries to manufacturers of specific projects. The Overseas Private Investment Office in Commerce also acts as a broker between foreign and American businesses. Inquiries from less-developed countries concerning both of these services amount to 30 to 40% of all requests. A small percentage of inquires addressed to the Smithsonian Science Information Exchange of the Department of Commerce also comes from clients in developing countries.

The U.S. private sector provides a varied range of scientific and technological information services by commercial, research, professional, educational and other institutions.[24] These services include specialized document collections, bibliographic databases, document delivery services, and information analysis. Since neither the public nor the private information services conduct any significant marketing in developing countries (with few exceptions such as NTIS, Control Data Corporation, Dr. Dvorkovitz and Associates), it is safe to assume that developing countries are unfamiliar with and unable to tap into the vast and complex American information service industry.

Outside the United States the major suppliers of information services to developing countries are various agencies of the United Nations family which aspire to become global information brokers to developing countries. Since the bibliographic information services of industrial countries typically provide poor coverage of the indigenous research or experiential

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[24] Slamecka, V. and McCarn, D.B. The Information Resources and Services of the United States: An Introduction for Developing Countries. Washington, D.C., International Science and Technology Institute, 1979.

literature of the less developed nations, U.N. agencies such as the Food and Agricultural Organization have stepped in with cooperative computer based bibliographic services that collect and dispense such information (the AGRIS, INIS, and similar services). In respect to their coverage of literature from industrial countries, these services compete directly with existing national and international systems operated by the industrialized countries. Some U.N. agencies, particularly UNIDO, endeavor to provide developing countries with information analysis services, pertaining to technological and decision making information; examples are the Industrial Information System (INDIS) and the Industrial Technological Information Bank (INTIB) of UNIDO. These latter activities are consulting in character, and so far neither extensive nor very efficient; UNIDO handles about twelve hundred requests per year (compared to ten thousand inquiries to the AID Division of Information and Utilization, and over twenty thousand inquiries to NTIS). Although many developing country policy-makers privately admit that the U.N. is unlikely to provide effective information services, some of the U.N. agencies nevertheless aspire to develop large staffs of information professionals, thereby competing with the information sectors of some of their industrialized member states.

In 1975 the United States proposed, at the U.N. General Assembly in Nairobi, that the United Nations gradually develop a "global network for sharing technological information." The General Assembly referred the proposal to the U.N. Office of Science and Technology with the mandate to develop specific recommendations regarding the nature and operations of such a network. A technical proposal[25] was submitted to the UNOST in 1979; coincidentally, it was compatible with the recommendations formulated by the United Nations Conference for Science and Technology later that year. The network proposal, which would facilitate access of developing countries to technological information resources and services in the industrialized countries, was scheduled for discussion at the fall of 1979

[25] Slamecka, V. Toward a Network for Global Information Sharing. New York, U.N. Office of Science and Technology, 1979. (Unpublished)

U.N. General Assembly but was withdrawn under pressure from several U.N. agencies which view the concept as competitive with their own operations and aspirations.

3. Freedom and the Flow of Information

The impacts, both beneficial and unwanted, of scientific and technological information on cultural and economic development seem partly determinable through controls on the flow of such information, many countries appear to believe. The quest to find generally acceptable borders between the free and the controlled flows is emerging as one of the more contentious international issues of the present decade. While this issue has many facets and wide-reaching ramifications, here we are concerned principally with those relating to scientific and technological information.

"Freedom of information" embraces the freedom to seek out information and ideas, the freedom to express opinions and to impart information by different means, and the freedom to receive information. Freedom of expression implies freedom of dissemination -- that is, a free flow of information, knowledge and ideas. Freedom of information appears to be the logical extension of freedom of thought. If freedom of thought is an individual freedom, freedom of information is both individual and collective. "The paramount importance enjoyed by freedom of information in the family of human and, especially, economic and social rights is explained quite simply by the fact that the right to inform and to be informed makes possible the exercise of all other rights."[26]

Until recently the United States felt that all that had to be said on the subject of freedom and free flow of information had already been written in the United Nations and the Unesco charters, and in the 1948 Universal Declaration of Human Rights. The International Covenant on Civil and Political Rights, adopted by the U.N. General Assembly on

[26] International Commission for the Study of Communication Problems, _Op. cit_., p. 64.

December 18, 1966, stipulated in particular that the right to freedom of expression "comprises the freedom to seek out, to receive and communicate information and ideas of all kinds, regardless of frontiers, whether in oral, written, printed or artistic form, or by any other means of the individual's choice." Such a view was quite satisfactory for the United States. In the past decade, however, the ideal that the flow of news, culture and data across borders ought to be completely unhindered, has been under scrutiny and even attack. The impetus for these actions comes from two directions.

On reaction questions the notion of freedom of information in the name of the notion of national sovereignty, suggesting that it is a tool of national domination. Such domination may be economic, cultural, and political. With respect to economic domination, we are told that poor nations need to control the flow of information to save their own development goals, that would otherwise drown in a one-way flow of commercial information from abroad. De Sola Pool dismisses the first two arguments, and offers substantial evidence that communications from abroad, particularly of scientific and technical information, promote development, including the development of domestic communication media.[27] The McBride Commission echoes this sentiment, pointing toward Japan's past experience and China's experience today which "suggest that certain benefits may be derived by developing countries from the information flow emanating from the technologically more advanced world."[28]

Strong economic overtones underlie also the "transborder data flow" issue currently under discussion among the industrial countries. This issue, which was early viewed as being motivated primarily by a desire to protect citizens' privacy (a cultural factor), has now spilled over into the economic domain, and it engulfs a significant portion of business and technological data. A number of countries, who have developed legislation

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[27]Pool, I. de S., Op. cit., p. 5.

[28]International Commission for the Study of Communication Problems, Op. cit., p. 66.

regulating the transmission of data about real persons, are now examining the possibility of extending such protection to data about legal persons (organizations). This further retreat from principles of free flow of information is due to wide-spreading concern with the economic viability of even strong countries. A recent world survey[29] reports that business, government and academic circles in 67 countries are equally divided on whether countries should restrict information highly relevant to their economic interests from being sent outside their borders. While 54% of respondents from the United States were against such restrictions, respondents from other geographic areas, including the developed, developing and Eastern bloc countries, were in favor of restricting such flows by a score of 46 to 34%. The impact of such restrictions is likely to be considerable.[30]

In many instances the primary reason for constraining the free flow principle is fear of the possible effect on the political systems and governing bureaucracies of given countries. It is primarily through censorship of ideas, political as well as technical, that dictatorships have been able to create and maintain in the minds of peoples a distorted image of other nations and their peoples, and thus forego domestic political and economic changes that are undesirable from the view of the country's political leadership.

The second major argument undermining the principle of free information flows is a peculiar interpretation that the principle connotes global guaranteed cost-free access to and use of information. Unesco has been particularly instrumental in defining the major role of communications in the field of science and technology as being "the management of human knowledge, the collective memory, i.e., all the information which societies need in order to progress in the modern world"; and, in the spirit of the

[29] Lloyd, A. "World Questions Free Flow of Economic Data," Transnational Data Report, Vol. 2, no. 7 (1980).

[30] Cf., Business Week, April 7, 1980.

New World Information Order as being "the common property of the international community." Some take this view to imply rejection of the concept of proprietary information which, if it prevailed, would seriously undermine the economic system of not only the free-market countries but of the world.

4. Information and Diplomacy

Scientific excellence and accomplishments have for ages enhanced the national image of national states as indicators of a nation's culture and its civilization. In rather recent times, the ability of a nation to perform scientific research and to apply its results to technology have been translated into political and national security terms.

In past ages, scientists did from time to time make important contributions to national defense and to industry, and in fact some of the world's greatest scientists worked quietly for their governments on matters of defense. But it is only relatively recently that science began to make a direct contribution to technology and to the productive powers of industry and thus to nations.

The United States became the world's technological leader from the close of World War I. World War II has shown clearly that national power, security, and economic growth were all directly related to the degree of support for the nation's R & D establishment, the efficiency of that establishment, and the ability of industry and the national defense systems to absorb and apply scientific findings.

Nations of the world have come to recognize technology itself as a principal foundation of national power, and the relationship between science/technology and national power became understood and translated into political terms.

As more nations perceived this relationship, a new concept was born -- that science and technology could be used for diplomacy, and that a nation could use its prominence in these areas for foreign policy purposes. The

French, especially under DeGaulle, were the first to fully understand this concept and its potential. Today, most foreign offices of the advanced nations have means to pursue diplomacy via science/technology. One such mechanism is bilateral scientific and technical cooperation among nations. These arrangements are made for the purpose of exchanging ideas and to improve each other's capabilities. The U.S. has some 40 bilateral arrangements today.

The quite spectacular scientific results of multinational and global cooperation in science and technology have had significant beneficial fallout in the area of politics and diplomacy. The international impacts of the International Geophysical Year, an ambitious venture in the international cooperation, "were every bit as spectacular as were the impacts on the United States and would be difficult to exaggerate."[31] The IGY contributed to the diplomatic framework for later negotiations leading to such developments as the 1961 Antarctic Treaty, the 1963 Test Ban Treaty, and the 1967 Space Treaty. It brought together Western scientists with Soviet and other colleagues who had been cut off from the Western world. Another positive effect was the Soviet agreement to join the International Copyright Convention in May 1973; prior to that the Soviets had reproduced thousands of papers annually from U.S. scientific journals in violation of the Convention.[32]

Many observers perceive a gradual trend toward international interdependence, replacing national isolationism in both the economic and the political domain. Although few nations in history have valued their independence more than the United States, with the growth of trade relations, this country has gradually moved toward a position of substantial dependence on other nations believing that "an interdependent world will intensify relations between states and people and place a premium on internationl cooperation."[33]

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[31] Bullis, H. The Political Legacy of the International Geophysical Year. Washington, D.C., Government Printing Office, 1973. P. 45.

[32] Physics Today 28:119 (January 1975).

[33] Report of the Commission on the Organization of the Government for the Conduct of Foreign Policy. Washington, D.C., Government Printing Office, 1975. P. 26.

C. Reciprocity in International Information Exchange

The United States is the world's single most prolific producer of verbally encoded information: about half of the world's scientific literature is either written or published, or both, in the U.S. (although 23% of it is due to non-U.S. authors).[33] Scientific and technological information that is not security-classified or held proprietary is said to be in the public domain, theoretically unlimited as to its availability. The United States has taken consistently the position that information generated with the assistance of public funds should be placed without delay into the public domain and widely disseminated. The use of such information is unrestricted except in the event that it is patented; and the use of the physical embodiment of such information (documents) is unrestricted except when protected by copyright. Substantial efforts are made -- often with the support of public funds and by government agencies -- to announce the availability of and disseminate such information. The multitude and variety of cataloging, indexing and abstracting services in the United States, both government-operated and commercial, is unsurpassed abroad. As a result, information in the public domain in the United States is said to be "fast-diffusing."

The United States distinguishes between public and private information according to the source of funds that supported the generation of such information. Proprietary information is kept private, as a kind of trade secret, until such time that the owner has no advantage in keeping it to himself. In the great majority of cases, the advantage sought is economic (although the rewards need not by any means be solely monetary): the ability to gain upon competition in the industrial, financial, or labor force markets. Proprietary information eventually does penetrate into the public domain, through encoding in products and services, movement of employees, and corporate realignments. Because this penetration is passive

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[33] Roderer, N.K. and Schell, C.G. Statistical Indicators of Scientific and Technical Communication Worldwide. Rockville, Md., King Research, Inc., 1977.

and largely involuntary, proprietary information is "slow-diffusing." The United States has no explicit policy of either encouraging or discouraging the release of proprietary information; it does recognize implicitly, however, that the concept of proprietary knowledge is important to nourishing the competitiveness of the free market economy.

With the exception of militarily strategic information, both fast- and slow-diffusing knowledge generated in the U.S. is available abroad. This is due to several factors: U.S. policies and practices that do not distinguish between domestic and foreign users; U.S. information supply services which actively pursue foreign information markets; and some foreign countries which make special, organized efforts to keep abreast of and obtain U.S. information. Foreign countries thus benefit from U.S.-generated information at a level commensurate with their interest in it, and with their ability to absorb and use it.

In its turn, the U.S. may appropriately ask whether and to what extent do Americans have access to and share the knowledge produced by other nations. The question resolves itself into two components: the willingness and helpfulness of other countries to make their information available; and the effort exerted by the U.S. to acually access such information and disseminate it domestically. These two aspects of reciprocity in international information flows are examined in this chapter.

1. Foreign Fast-Diffusing Information: National Policies

For reference, tables 10-13 show some available data relating to the estimated worldwide production of verbally-encoded, publicly available information. They cover the production of books (Table 10), scientific journals (Table 11), and patents (Table 12). Table 13 illustrates the growth of the world's abstracting and indexing services through which one normally finds relatively efficient access to scientific literature. There are no reliable worldwide statistics on the production of technical reports; their annual volume probably approaches 400,000, with the United States and Soviet Union each contributing approximately 100,000 reports.

With two major exceptions, the policies governing the management of information produced by other industrialized countries approximate those of the United States in that scientific papers published in journals and conference proceedings, monographs and patents are considered to be in the public domain and are distributed through the regular publishing channels. The bibliographic control of these items is relatively well developed, and the coverage by national and international cataloging, abstracting, and indexing services is adequate. The principal exceptions to these practices are technical reports (documents emanating from government supported research and development) and information on current R & D projects.

In most countries, the bibliographic control and dissemination of technical reports on government-supported R & D results lag substantially behind the practices of the United States. Surveying the bibliographic control of technical reports outside the U.S. we observe that the United Kingdom, West Germany and the Soviet Union are providing financial resources for improving access to reports on government-funded research and development; bibliographic control in other industrialized countries, particularly Japan and France, is quite inadequate. The following is a short review of current practices and developments in these countries.

- In the United Kingdom, the Department of Industry established a Technology Reports Centre (TRC) to provide access to the technical report literature. The Centre acquires and indexes U.K. reports and publishes R&D Abstracts, a semi-monthly journal of abstracts of science and technology reports.

- West Germany seems to be the only other country of the Western industrialized world to be making a serious effort to provide bibliographic control of the report literature. FIZ4 is expanding its coverage of the technological report literature, but the lack of reporting of R & D results persists.

- Japan provides what is described by one source as "completely fragmented" coverage. The coverage is divided by prefecture for some areas, or by subject. The Japan Information Center for Computer Science and Technology (JICST) provides very good coverage of material within its areas of interest. The U.S. publication STAR is said to provide far better coverage of the Japanese technical report literature than the international service INIS, a U.N. system.

- o Coverage of R & D results in France, which has a nationally supported bibliographic database (the PASCAL system), is considered to be so inadequate that a totally new French report literature component for the future European Economic Community (EEC) database is being proposed.

- o A white paper is being prepared on the proposed EEC project. The available information indicates that the EEC is responding to a widely-expressed need for better coverage of the results of R & D in both the public and private sectors within the Community countries. (For example, a subgroup on research registers has been established within the U.K. Interdepartmental Committee on Scientific and Technical Information to coordinate U.K. input to the EEC.)

- o The agency of the Soviet Union charged with registering research projects and disseminating "unpublished" reports generated anywhere in the U.S.S.R. is the All-Union Scientific and Technical Information Center, in Moscow. The Center became operational in January 1968. It registers approximately 100,000 R & D projects each year; some 100,000 engineering design projects; 75,000 technical reports; and 30,000 dissertations, as well as theses currently in preparation. The Center is said not to process reports which involve the national security of the U.S.S.R. Research projects are listed in a Bulletin of Registration published in more than 30 subject categories and issued at various frequencies. The Center's abstract journal, Collection of Abstracts on Scientific Research and Experimental Design, is published in 26 series. A bulletin, Algorithms and Programs, constitutes a registry of available computer programs and algorithms deposited with the Center. All these publications are "for official use only." The restricted distribution is said to be due to the fact that the reports and theses represent work not yet completed or patented. Furthermore, the Center provides service only to government organizations, not to individuals. Restricted exchange arrangements do exist with other countries belonging to the Council for Mutual Economic Assistance.

Similarly, foreign inventories of research projects sponsored by public funds lag considerably behind the efficient and relatively comprehensive U.S. system operated by the Smithsonian Science Information Exchange. Recently, the SSIE produced a catalog of foreing research projects[34] which indirectly reflects on other countries' attempts at the bibliographic control of this information. The most complete inventories of research projects

[34] Information Services on Research in Progress; A Worldwide Inventory, Washington, D.C., Government Printing Office, 1978.

outside the United States are those of the United Kingdom and of the Soviet-bloc countries. Information on U.K. research in progress is provided in Research in British Universities, Polytechnics, and Colleges (Volume 1, Physical Sciences) published by the British Library Board and compiled and edited by the British Library. This is a new national register of scientific research of the U.K., whether funded by the government or not. The three-part register will be issued annually. The research inventories of the U.S.S.R. and East Europe are not open to general use by the public, even within the countries themselves.

2. Availability of Foreign Fast-Diffusing Information in the United States

Given the strong (albeit eroding) financial support of U.S. research libraries, the tempting assumption is that most of the world's significant publications are being acquired somewhere in the United States. This assumption cannot be verified by published statistics because they do not generally distinguish between foreign and domestic publications acquired by U.S. libraries. There is, however, some evidence to suggest that a significant percentage of foreign scientific information is not available in the United States. The following comments summarize the situation.

- The contents of serial publications are generally accessible through a wide range of indexes and abstract journals, both U.S. and foreign and both general and discipline-specific. New Serial Titles[35] identifies and locates specific serial titles, just as the National Union Catalog[36] identifies and locates specific monographs. Accessibility of these two reference tools around the country should enable scientists, through their local libraries, to tap the resources of most major collections, by means of inter-library loans and photocopying. A 1969 study, however, reported that of 70,686 interlibrary loan requests for scientific publications filed at the 325 libraries surveyed, 11,202 were unfilled.[37] Another 1969 study for the U.S. Office of Education

[35] New Serial Titles; A Union List of Serials Commencing Publication after December 31, 1949. Washington, D.C., Library of Congress, 1953-

[36] National Union Catalog; A Cumulative Author List. Washington, D.C., Library of Congress.

[37] Wood, J.L. A Review of the Availability of Primary Scientific and Technical Documents within the United States. Bethesda, Md., U.S. Office of Education, 1969. Vol. I, p. I.4.

reported that of 3,197 core serials identified as having prime importance to various scientific and technical disciplines, 608 were only partially represented in the collections of 325 libraries surveyed and 24 core serials were not represented at all. More recently, statistics compiled by Chemical Abstracts reveal gaps in the science and technology holdings of 327 major American libraries: of 18,684 current serials, 1,949 were not represented at all; out of a total of 9,960 conference proceedings, 1,133 were not found; and 1,158 monographs of 8,374 listed were not held by the reporting libraries. While the survey focused primarily on chemistry, other fields in science and technology were widely represented. Approximately 25% of the data base for this survey represents U.S. publications and 75% foreign.

- Although statistics are lacking, it is likely that the availability in the U.S. of scientific information generated by developing countries is sporadic at best. In contrast to the Soviet Union, whose national information systems have as their explicit goal the collection of all such information regardless of place of origin, language or form of publication, acquisition policies of U.S. information-systems and libraries make little attempt to collect systematically scientific and other recorded information which appears in less industrialized countries and in lesser known languages.

- Foreign patents[38] are generally accessible through the Office of Technology Assessment and Forecast (OTAF) of the U.S. Patent and Trademark Office and at more than 33 Patent Depository Libraries across the nation. Each year the OTAF receives, but does not add to its computerized database, about 280,000 new foreign patents; these patents are accessible only through the PTO headquarters in Arlington, Virginia. (In contrast, over 200,000 U.S. patents have been issued since 1970 to residents of more than 100 foreign countries.) The Domestic Policy Review has pointed to the need for better accessibility of foreign patents.

- There is strong evidence that U.S. access to foreign technical reports is wanting. A recent report has concluded that the U.K., France, the Federal Republic of Germany, the Netherlands, and Japan "produce at least 100,000 technical reports annually that do not reach the United States in any form. . . . Possibly a third to a half of the reports would be of interest and use in the U.S. economy."[39] The Library of Congress

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[38] Houghton, B. Technical Information Sources; a guide to patent specifications, standards, and technical reports literature. London, C. Bingley, 1972. P. 79.

[39] Domestic Policy Review Task Force on Patent Information, 1979, p. 4.

currently receives only about 20,000 foreign technical reports annually, chiefly from Western Europe and Japan; these are indexed or abstracted by services such as Nuclear Science Abstracts or Scientific and Technical Aerospace Reports. (Probably the world's largest collection of technical reports is in the British Library Lending Division at Boston Spa. This collection, totaling over two million documents, includes virtually all U.K. technical reports, all U.S. AD and PB reports on microfiche that do not have restricted circulation, and a substantial number of foreign reports. The BLLD collection contains Ministry of Defense reports which are available from the TRC. Reports in BLLD are available on loan or through photocopy to interested parties in the U.K. and elsewhere. The U.K. reports are not indexed as extensively as those in the U.S., however. Except for certain restricted material, U.K. reports seem to be as available as U.S. reports are.)

- Translations of periodical articles and technical reports by the Special Foreign Currency Science Information Program are available through the National Technical Information Service which publishes Government Reports Index.[40] NTIS, which also makes available translations of scientific monographs, is expected to increase sharply its activities in this area in response to the Domestic Policy Review.

3. Foreign Slow-Diffusing Information

Given that the results of industrial research and development are kept a closely-guarded secret by most companies in countries with free market economies and by the state in countries with a planned economy, it is difficult to estimate and measure the respective flows of this information from and to the United States. The principal means by which this information is transmitted are products and services, technical meetings, intercorporate movement of employees, and multinational industry operations. The house journal literature issued by companies primarily as a public relations vehicle provides a very uneven and sparse source of information on current and completed R & D activities. One study[41] has identified that of the large numbers of house publications only a small group --

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[40] Government Reports Index. Springfield, Va., National Technical Information Service, 1965-

[41] Griffith, B.C., et al. Aslib Proc. 27(1975):375-384.

approximately 125 in the U.S. and 100 in the U.K. -- provide some information on current research and development. (The study also found that some companies actually seem to publish articles on areas in which they were not working, so as to "throw off" the competition.) As a result, statistics concerning the volume of foreign technological information are scarce.

Regarding the access to and availability of foreign marketing information, a recent report states that "the existence of such information is either unknown to or the information does not adequately serve the needs of smaller businesses and is largely ignored by them. The information is often too general or is incomplete with regard to the details of interest. It fails to identify and qualify trade and technology opportunities in a timely manner. It fails to deal effectively with barriers that have insulated business from foreign markets."[42]

Clearly, the value of foreign technological information is high and increasing, in view of the expectations that the majority of future advances may come from outside the U.S. because "as much as two-thirds of all research and development is now conducted by foreign laboratories."[43] Since one cannot expect foreign governments and industries to publicize and widely disseminate technological information that is a key to their competitiveness in markets, the question of international reciprocity in the flow of technological, slow-diffusing information boils down to that of the scope and success of U.S. efforts to tap these foreign information resources.

Presumably, the most effective mechanisms are multinational operations and joint foreign ventures; the technical intelligence gathered through these operations is not regularly shared and disseminated in the U.S., however. Activities and assistance of the U.S. government have had mixed results.

[42] Draft Report on Information Policy, p. 17.

[43] Ibid, p. 14-15.

For example, the usefulness of the science attache program for the collection of technological information through U.S. embassies abroad is understandably limited. While a strengthening of it has been proposed, it is unlikely that the diplomatic service can generate a robust flow of technological, slow-diffusing information from abroad to the U.S., and that it can -- or should -- be responsible for the dissemination of this resource. Similarly, the International Trade Administration of the U.S. Department of Commerce has not in the past been a major channel for transferring and disseminating foreign technological information in the United States.

Foreign travel regulations of the U.S. government affecting grantees and contractors illustrate the lack of foresight of official policy. The U.S. can hardly remain well-informed about foreign science and technology with-face-to-face contacts with foreign scientists and technologists, and without visits to foreign laboratories and production facilities. Unfortunately, such contacts and visits are being stymied by decreased or frozen budgets for foreign travel; also dues for membership in international organizations have lately come under severe scrutiny. Such restrictions may seem appropriate at a time of economic belt-tightening but their effect is to foreclose or make less effective contacts with foreign science and industry.

Some very recent actions of the U.S. government are encouraging. The U.S. Department of Commerce is implementing a worldwide service on trade information (WITS), a computer-based network that will collect, through U.S. embassies abroad, information on marketing opportunities, products, etc. Another example of the government's planned activities is the expanded mandate of the National Technical Information Service to collect and distribute technological information emanating abroad, of both the fast- and slow-diffusing types.

D. Conclusions

The discussion presented in this chapter lends support to the following conclusions:

1) The economic value of U.S. scientific and technological information is enormous. Several recent studies of agricultural and manufacturing industries have established that the rate of productivity increase of these industries or their firms was directly related to the amount spent on R & D.[44] Given that the major product of R & D is new knowledge (in a wide sense of the term), it may be argued that these studies establish a direct relationship between the generation/application of new knowledge and the rate of productivity. This is not to claim that the development and/or application of new information are a sufficient condition for productivity to increase. However, the fact that such an empirical relationship between knowledge and productivity does exist renders scientific and technological information to be a national resource of enormous value, since it is well known that the rate of productivity growth affects the rate of economic growth and the competitiveness of goods and industries in international markets.[45]

The studies of the relationship between R&D and productivity show somewhat lower returns for industries where the R&D was financed by government, as compared with privately financed R & D; there is, however, some uncertainty about the actual magnitude of the difference.[46] Whether such difference holds for the impact of public vs. proprietary information use (being the result of, respectively, publicly and privately supported R & D) is a moot point at this time.

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[44] Mansfield, E., "Research and Development, Productivity, and Inflation." Science 209:1091-1093 (September 5, 1980).

[45] Council of Economic Advisers, Annual Report. Washington, D.C., Government Printing Office, 1979. Pp. 67-72.

[46] Mansfield, E., Personal communication, September 9, 1980.

2) The United States generates, at a national cost running into tens of billions of dollars, close to a half of the world's scientific (public-domain) information, and an unknown but probably comparable proportion of technological information that is considered proprietary. It is difficult if not impossible to assess whether or not the cumulative returns to the U.S. for sharing this knowledge resource with the rest of the world are adequate; at best we can only sketch the nature of the balance sheet, as follows.

Direct and indirect export of this resource through the information service industry is estimated to generate an income of under $2 billion; compared to our expenditures for importing foreign information, which are substantially smaller, this is a favorable although not overwhelmingly important trade balance. Other benefits that accrue to the United States are cumulatively considerably larger. In random order, they include: repatriated profits from U.S.-based firms' foreign operations (exports, foreign manufacturing); income from patent and technology licenses; U.S. firms' smoothed income stream from foreign profits which are not synchronized with the U.S. business cycles; reverse technology transfer; exports of goods related to those manufactured abroad (a marketing phenomenon); increased attractiveness of U.S. jobs that become more interesting and require higher skills as low skill tasks are transferred abroad; narrowing of the have/have not gap; the likelihood that nations which have more ongoing economic ties to the U.S. will take politically sympathetic positions; and a better understanding of the U.S. on the part of foreign nationals.

On the other side of the trade-off equation the U.S. accrues substantial risks. The greatest is the price of foreign competition to U.S. firms, with all its attendant byproducts such as loss of profits and jobs. This effect is particularly ominous for U.S. high technology industries that may encounter long-term competition from foreign firms with much lower, sometimes government-subsidized costs. Another huge risk and potential cost comes from military application of U.S. technical information by foreign powers, inasmuch as the line between strategic and non-strategic technologies is increasingly difficult to draw precisely.

3) It has not been possible in this study to measure the impact of U.S.-generated information on the growth of productivity and/or competitiveness of other industrialized countries -- growth that surpasses the rates of productivity in many U.S. industries. It is demonstrable, however, that scientific and technological information is being heavily acquired by these countries: fast-diffusing information through direct purchase of documents, slow-diffusing information through international corporate operations and persistent attention to the private sectors of the U.S. economy. The governments of these countries clearly perceive the potential and value of new knowledge, and they are pursuing systematic, organized and nationwide promotion and application of such information with single-minded intensity.[47]

4) There exists a detectable imbalance between the international availability of U.S. results of R & D and the inflow to the U.S. of scientific and technological information generated by other countries. The imbalance is particularly pronounced in respect to technical reports and to technological information of the proprietary type. The primary reasons appear to be several: a) some countries have more restrictive, or less specific, policies for relegating some information into the public domain; b) foreign bibliographic control of some information is inadequate; and c) the U.S. lags behind some countries in efforts at systematic and intensive search for and exploitation of foreign information resources, especially proprietary information, partly because American users do not always attach sufficient importance to foreign information.[48]

5) Many of the issues involved in international information transfer directly affect the U.S. information service industry and its future in international markets. Increasingly, these services find themselves

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[47] Cf., Slamecka, V. and Borko, H., eds., Planning and Organization of National Research Programs in Information Science. N.Y., Pergamon Press, 1980. (In press).

[48] For example, all citation studies show that U.S. publications receive the highest number of citations worldwide. Cf, King, D.W., et al, Statistical Indicators of Scientific and Technical Communication, Rockville, MD, King Research, Inc., 1978.

competing for user markets with foreign services and, in some cases, with international consortia. The issue of future viability of U.S. information services in international markets primarily arises as a result of three factors: a) the desire of foreign governments to have a healthy national information industry serving domestic users as well as international markets; b) the economic challenge posed by the electronic technology of digital storage and transmission which preempts the need to issue documents in large numbers of copies; and c) the declining international respect for legal conventions such as copyright that govern and limit the right to reproduction of information embodying documents, and thereby deprive publishers, database vendors, and document supply services access to relatively large markets which assure their economic viability at the lowest product service price.

(6) The United States' posture regarding the transfer of scientific and technological information to developing countries is in need of better definition. On the one hand, the U.S. acknowledges that knowledge and socioeconomic development are intertwined; that the latter is not conceivable without the former; and that sharing our information resources with less advanced countries is prudent. On the other hand, we do not seem to understand fully the differences that characterize the clientele of developing countries, its idiosyncratic information requirements, and the need to rethink our concept of information service. Nor do we seem to grasp fully that the economic considerations of information transfer to developing countries have a different basis, both as regards the value of U.S. information and the payments for our information services.

Partly due to these factors the U.S., which has generated dozens of proposals for action and programs in this area,[49] lacks a clear strategy.

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[49] See "Summary of Previous Recommendations" in Slamecka, V. "Information for Developing Countries; Suggestions for a U.S. Position." In: U.S. Senate Committee on Labor and Human Resources, Op. cit., p. 126-128.

Our approach appears to treat developing countries not differently than industrialized nations; that is to say, we consider information as a "part" or a "commodity," to be provided to or procured by developing countries within the framework of separate, individual projects or programs -- industrial, scientific, or educational. Since the U.S. information service sector is usually included in these projects only as an afterthought (if at all), the flow of information and the information service support to developing countries are sporadic and uneven.

What appears lacking from the strategy of U.S. agencies interacting with developing countries is a complementary view and perception of scientific and technological information as a homogeneous, discrete developmental resource. Operationally, such a supplemental strategy should seek to build up in these countries the proclivity, infrastructure and mechanisms that are necessary for the effective use and application of this resource. Such a strategy would strengthen and institutionalize long-term information flows between the United States and the developing world, its benefits being mutual. (It is noted that the first, so far isolated, attempt in this direction is underway in Egypt.)

III. RECOMMENDATIONS

There are two generic issues that concern the United States in the area of international flows of scientific and technological information: the value of this resource as an article of exchange, and the competitiveness of U.S. information services in international markets. The concern on the first score is that our international management of this costly resource is less than optimal; specifically, that the United States does not reap commensurate benefits from sharing this resource freely with other countries. We should seek, it is believed by some, to extract a more equitable price in one form or another, or else develop flexible management controls on the export of new knowledge that would reduce the negative effects that our policies of global information sharing have on the U.S. economy.

The second issue, that of the competitiveness of U.S. information services, arises because of the lack of internationally agreed-upon and observed conventions for the conduct of business in this area, particularly in view of the rapid growth in many countries of strong, internationally-competitive information industries.

The two issues are not unrelated; action on one set inevitably impacts the other set of concerns. Clearly, policies regarding the management of international traffic of scientific and technological information have nontrivial impact on information services of all countries, in both national and international markets.

The purpose of this chapter is to offer suggestions and recommendations intent at improving U.S. positions on these two scores.

A. Increasing U.S. Returns from Scientific and Technological Information

The benefits from international exchange of scientific and technological information are not necessarily distributed equally among the trading parties, and it is natural for any country to seek tilting the trade-off balance in its favor. There are three basic strategies that may be used toward this end: 1) an intensification of the national exploitation of information generated domestically, a strategy particularly appropriate for countries that account for substantial R & D investments; 2) effective ways of bringing foreign information into the country and promoting its application, a strategy essential but by no means limited to countries with modest R & D investments; and 3) implementing controls on the export of domestically produced information.

Whereas the flow and diffusion of proprietary information are largely controlled by forces of national and international markets, the defensive strategy of controlling the foreign distribution of fast-diffusing, public information is likely to be ineffectual. This is due to several factors; among them being the many channels through which this information flows and is dissipated; the entrepreneurial efforts of national information services abroad; the impracticability of differential pricing methods that would distinguish between domestic and foreign buyers, among foreign buyers and users; and the general undesirability of reversing the global objective of unhindered information flows.

Although there does not exist complete agreement in the United States regarding the principle of uninhibited international exchange of information, especially regarding design and manufacturing information,[50] the thrust of present and past U.S. policies is clearly supportive of it. For instance,

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[50]U.S. Department of Denfense. Defense Science Board. An Analysis of Export Control of U.S. Technology -- A DoD Perspective. Washington, D.C., Office of the Director of Defense Research and Engineering, 1976. 39p.

the U.S. National Academy of Sciences has recently posited the following "national goals" in this area:[51]

1. To improve the worldwide flow and exchange of scientific and technical information as an economic, social and cultural force, with the aim of improving the quality of life.

2. To improve access to scientific and technical information, especially that generated outside the United States, for the advancement of American science and technology.

3. To assist developing nations to increase their indigenous capabilities for organizing, acquiring and applying scientific and technical information.

4. To promote internationally the use of United States scientific and technical information systems, services and products.

This study endorses these goals; the salient theme in our national policy of information management is the utility and use of knowledge, not its existence. With this theme in mind we propose several steps that can, in our opinion, increase the U.S. benefits derived from scientific and technological information exchange.

1. Although the outflow of U.S.-generated information, particularly of the technological variety, does stimulate foreign economic competition, the consequences are not unilaterally disadvantageous for the United States. Rather than inhibiting international exchange of U.S. information that has been relegated into the public domain, the United States should take measures to enhance the domestic utility of newly generated information to our own economy. Such an effect may result from a critical examination of the different functions that scientific and technological information plays

[51] National Academy of Sciences. Committee on International STI Information Programs. Goals and Objectives for the United States Participation in International Scientific and Technical Information Activities. Washington, D.C., National Academy of Sciences, 1977. 4p.

in social and economic processes, and from the establishment of differential dissemination policies and practices that maximize these functions and processes.

The present[52] and the proposed[53] policy of the United States implies that whenever information is generated with the assistance of public funds (government contracts and grants) it is a public "good," and the government should see to it that it is immediately placed at the widest possible disposal of others. The underlying premise holds that the greatest social benefit of information will be realized when it is given the broadest distribution (i.e., when the largest possible numbers of individuals and/or organizations are given the opportunity of using new information), While such a premise is valid in science and for the scientific community, its absoluteness is doubtful. Information, particularly of the technological variety, often functions as a "part" of a process whose goal is not the creation of information but the design, development or production of certain goods.[54] The goal is realized (and presumably society benefits most) only when that process is completed. Clearly, premature divulging of data and information that has such an instrumental role may discourage its author/owner from committing the investment often necessary to transform knowledge into a product, process, or service, since his competitive edge may have eroded.

As a result, we surmise that new technical knowledge in the United States often lies fallow, and the practice that places such information into the public domain for the greatest national benefit may have exactly

[52] Federal Council for Science and Technology. Policies Governing the Foreign Dissemination of Scientific and Technical Information by Agencies of the U.S. Federal Government. Washington, D.C., Executive Office of the President, March 1968. 3p.

[53] Office of Management and Budget. "Improved Management and Dissemination of Federal Information." Federal Register, June 9, 1980.

[54] Nugent, W.R. "The Information Intensive Community." Proceedings of the Third Indo-U.S. Workshop on Modelling of National STI Systems, New Delhi, India, March 1980.

the opposite effect. That is to say, the government's policy and practice to widely distribute new technological information may actually inhibit the use of some of this information, and hence be counter-productive to the primary objective for competitive governmental support -- to stimulate the production of new and improved goods and services to its people -- because the successful competitors may not get involved.

We therefore recommend a study to examine the question of proper, optimal timing of the diffusion of information generated with public support, and to determine the feasibility of formulating criteria that discriminate, to the extent possible, between efforts whose primary purpose is to generate new knowledge and those in which new information is temporarily an instrumentality. If such criteria are feasible, it should be possible to devise appropriate Federal guidelines and operational procedures that seek to maximize the probability of use and application of U.S.-generated information.

2. Even temporarily withholding new information from the public domain is tantamount to keeping it proprietary. Proprietary information, most of which is the result of private investment, is not a public good; the primary benefit comes from maximizing its utility potential, usually in the process of improving the design of goods or services for the consumer market. This process, which is highly competitive, is the basis of technical progress, and thus both the owner and society generally benefit from withholding certain information from potential competitors until it can be embodied in a product, process or service. The above par value of such information has engendered conventions that protect its proprietary characteristics.

The concept of proprietary information is widely misunderstood outside, but also within, the United States, and often it is objected to for idealistic, economic or political reasons. To the U.S. and to the rest of the world alike, the concept is essential if the current principles of behavior of the world economy are to be maintained. In free-market economies, which function and thrive on internal as well as international competition, technological information provides the primary competitive edge to its possessor. In the planned economies of industrial countries, as well as those of many developing countries, the principle of competitive innovation operates largely at the international level; thus while the possessor of economically valuable information is expected to release it, the diffusion and availability of such information is often strictly controlled. The Soviet-bloc countries make full and uninhibited use of such controls; even though by their definition all information -- scientific and technological -- is generated in the public sector, we have seen that technical reports are clearly "proprietary" to the Soviet state. (The Soviets simply declare their technical reports to be "unpublished.")

The attack, by some developing and some socialist countries, on the concept of proprietary information has far-reaching implications in the long run. Unfortunately, the U.S. does not seem to have a clear understanding of the notion of proprietary information, nor are we quite certain what are its properties, and what are the best ways to manage it, both domestically and internationally. As a consequence, our spokesmen are usually unable to present a strong posture on this issue at the various international forums. It is essential that we clarify, for ourselves and others, the concept of proprietary information, its properties, and its role in domestic and world economy.

We therefore recommend a study project, or an invitational roundtable, to discuss a set of carefully developed propositions relating to the concept of proprietary information. The project should be followed by an intensive campaign to embue the understanding throughout the decision-making levels of the private and the public sectors.

3. A complementary issue is the availability and use of foreign infomation in the United States. Whereas one may assume that most of the content of foreign scientific journals is known to and largely available in this

country (although it is relatively lightly used), the same assumption cannot be made about U.S. awareness of and access to non-serial literature and to foreign technological know-how. Cognizant of the declining U.S. access to information in an era in which foreign science and technology are increasing in both volume and importance, the U.S. government is already taking a number of actions aimed at halting this trend.[55] In order for the effort to gather, analyze, and disseminate information regarding foreign science and technology to acquire sustenance, continuity and breadth, we believe greater participation is required by the science and technical community of the United States. This community should intensify and systematize its efforts to sift through, analyze, and disseminate technical information generated by foreign industrial laboratories and organizations.

The crucial aspect of this activity is information value analysis. It is well-known that much of the published and unpublished information, both scientific and technological, has a low utility potential and often low quality. The collection and processing of such information is an extremely costly enterprise, and must be guarded against in the otherwise desirable attempts to widen U.S. access to foreign information. The point is that technical professionals themselves, rather than information acquisition agencies (libraries or federal agencies such as NTIS) are best qualified to render such value judgments. Professional associations concerned with production technologies are particularly suitable candidates for this role and for developing criteria to gauge the value and economic relevance of foreign technological information.

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[55] In his Message on Industrial Innovation, the President has proposed an initiative to gather unpublished technological information by sending business and technical teams abroad; he has urged NTIS to become more active in gathering, organizing and disseminating published and unpublished technological information from abroad; and he has instructed U.S. missions abroad to become more active as focal points in the gathering of such information. In addition to these initiatives other government agencies are involved in related programs, exemplified by the CIA's Civilian Technology Assessment Program.

Therefore, we recommend that the Department of Commerce urge U.S. scientific societies and professional-technical associations to undertake the dynamic collection, analysis, evaluation, and dissemination of foreign technological information. These activities may proceed via different strategies, such as organizing invitational meetings or workshops of carefully selected international experts and promptly generating and disseminating analytical syntheses of the subjects of these workshops; and contracting for the evaluation of technological information with competent analysts located overseas and working from places at which such information is gathered (such as the British Library Lending Division or the future databank of technical reports of the European Economic Community).

B. Strengthening the U.S. Information Service Sector

Many of the issues involved in international information transfer directly affect the U.S. information service industry and its future in international markets. To this industry information is embodied in commercial products and services, and the viability of these is a function of the existence of markets, and of access mechanisms to the products and services. The economics of this industry does not allow much redundancy of some services, and as the computer/communications technology opens the services to global markets, U.S. services find themselves competing for user markets with foreign services and, in some cases, with international consortia. The continuing viability of this sector in international markets primarily arises as a result of the following three factors:

- Foreign governments desire to have adequate stores of information resources located within the country, so as to be self-sufficient (in the case of war, for example); to have a healthy national information industry, so as to grow and provide jobs; and to accomplish this in part by having domestic information consumers purchase services from domestic information firms. Most industrialized countries thus are seeking to establish a national industry for information management and services. This industry does not limit itself to the management of vernacular, domestically produced information; rather its purpose and objective are to access and ready for domestic use any item of information that can improve the country's competitive posture, especially internationally. Beyond this purpose, these information industries (of industrialized as well as of some industrializing countries) are seeking to serve markets beyond their national borders, markets which lie in both industrialized and developing countries; sometimes they do so under more advantageous conditions, being aided by subsidies from their governments.

o To be economically self-sustaining, publishers, database vendors and document supply services require access to relatively large markets (in terms of thousands of customers). Traditionally such markets for information have been protected by the device of copyright, a legal convention that governs and limits the right to reproduction of information-embodying documents. Copyright assures its owner of the largest possible market; in turn he is able to provide the document/information at the most economical price. Whenever the copyright does not exist or is ignored, the market is partitioned among competing services and the service costs are driven up. The internationally growing number of information services (e.g., indexing and abstracting services) which process similar or identical information necessarily has this effect.

o Information supply services face a considerable challenge posed by the electronic technologies for data storage and transmission. For an electronic market, a digitally stored document need not be issued in large numbers of copies; any number of users can read the master copy off the screen, and optionally generate a physical "hard" copy. An information supply service thus needs to obtain (or produce) only one electronic issue of a document to be able to distribute unlimited numbers of copies. While the economics of such supply systems has not yet settled down, it is likely that electronic means of information transfer will be more economical than present-day methods.

We suggest several steps to be taken to strengthen the U.S. information supply industry, both public and private, in its international activities.

1. A key to assuring the viability of U.S. information supply services in international markets is an international agreement on a set of voluntary principles to guide marketing of foreign information within and outside the orders of each country, and to guide the economic behavior of information supply services in global markets.

Therefore we recommend that the Department of Commerce sponsor a collaborative effort by components of the public and private information sector to formulate a U.S. proposal governing the economics of information supply services in global markets. Such a proposal should incorporate adherence to the copyright principle, and suggest a mechanism for an international system of payments for the reproduction of copyrighted information carriers (printed matter, computer programs). Since adherence to the copyright principle is, of course, effective only for information carriers that are actually copyrighted, the Department should continue examining the possibility of by-default copyrighting a variety of information resources produced with public funds that, for one reason or another, now reach the market without copyright.

2. In our judgment, the U.S. information service industry of the private sector has a major opportunity to provide useful, effective and rewarding functions associated with the socioeconomic development of developing nations. The benefits of these functions can by far surpass both the investment and the remuneration involved. We have noted that information transfer has a range of social and political effects whose worth is perceivable but not measurable. These effects are of particular significance in our relationship to the majority of mankind that comprises the developing nations of the world. Their knowledge needs are enormous and must not be ignored.

To alleviate this need, the perhaps single most urgent action is to facilitate the developing countries' access to U.S. information resources and services. President Carter's Special Assistant for Information Management has identified sixteen Federal organizations providing technical support services to the developing countries, and concluded that "not much action has been taken toward creating and coordinating a structure that would make it easier for the developing countries to take full advantage of the information made available by these organizations."[56] (The Federal

[56] R.M. Harden, "The Process of Development: Helping Managers Become Information Efficient." Paper presented at the OECD Meeting on the Knowledge Industry and the Process of Development, Paris, June 1980. 23p.

agencies mentioned are the Departments of Agriculture, Commerce, Defense, Education, Energy, Health and Human Services, Housing and Urban Development, Interior, Labor, State, and Treasury; the EPA, NASA, Peace Corps, Smithsonian Science Information Exchange, and Federal Laboratory Consortium.) Apart from the Federal information resource, a wealth of highly desired information regarding technology -- that is, policy-making, economic, industrial, marketing, business, operational and legal data and experiences -- is in the hands of organizations and individuals from consulting firms, equipment manufacturers, suppliers of capital equipment, producers, financial organizations, salesmen, and other groups. The ability to mediate not only access to but also the use of information is the hallmark of the U.S. information service sector. This sector can be of most valuable assistance to developing countries provided the channels of communication are opened up.

In order to enhance the development-oriented utility of U.S. information resources and services, it is therefore essential to provide an effective coupling mechanism between them and the prospective clientele in developing countries. Such a mechanism has two facilities: a referral point in the United States, and modern communications. There is little doubt that both facilities will eventually evolve, and that once in existence, they will be instrumental in defining and structuring global information markets. This fact has not escaped U.S. competitors in these markets, including the U.N. and the OECD, who are busily planning strategies and projects oriented at the developing world. The U.S. Government should play an urgent, catalytic role in the development of a better coupling mechanism between developing countries and the U.S. information service sector.

Therefore, we recommend (1) the establishment in the United States of a focal point to provide developing countries assistance in locating and accessing the sources of relevant technological information in the United States, and to mediate contacts between these countries and U.S. supply and analysis information services in both the public and the private sectors; and (2) the establishment *preferably by the private-sector information industry, of a communications facility enabling the digital transfer of messages between U.S. information services and their clientele in developing nations.*

Admittedly, information services to developing countries cannot be guaranteed monetary profits in the short run; it is precisely because the benefits to the U.S. are political and diplomatic that it is appropriate for our government to provide support of less-than-fully remunerative activities of the private sector in this area. In the long run, however, the argument for an early involvement of U.S. information services in developing country markets is an economic one, and it is based on both the future potential of these huge markets and the competing forces currently being organized by other industrialized countries.

Table 1. R&D Expenditures as a Percent of GNP, Selected Countries, 1961-1977.

YEAR	United States		France		Germany		Japan		United Kingdom	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
1961	2.74	1.34	1.38	0.98	NA	NA	1.39	1.37	2.39	1.48
1967	2.91	1.87	2.13	1.59	1.97	1.81	1.53	1.52	2.33	1.68
1972	2.43	1.66	1.81	1.55	2.33	2.18	1.85	1.84	2.06	1.53
1975	2.30	1.62	1.82	1.39	2.39	2.23	1.94	1.93	2.05	1.52
1976	2.27	1.57	1.74	1.47	2.28	2.15	NA	NA	NA	NA
1977	2.25	1.59	NA	NA	NA	NA	NA	NA	NA	NA

NA: Not available

Source: U.S. Department of Labor, Office of Productivity and Technology, based on data from the National Science Foundation, April 1979.

(1) Total R & D expenditures.

(2) Total R & D expenditures excluding expenditures for national defense.

Table 2. Resources (1) Devoted to Industrial R&D in OECD Countries in 1975 (or Nearest Year)

		R & D Manpower		R & D Expenditure		RSE	
		Thousands FTE	%	$ million (1)	%	Thousands FTE	%
Major Industrial R&D Effort	United States	767.8 (2)	43.3	24,164	49.8	362.8	50.1
	Japan	308.7 (3)	17.4	5,658	11.7	145.2 (3)	20.0
	Germany	186.2	10.5	5,881	12.1	61.6	8.5
	United Kingdom	180.2 (3)	10.2	2,964	6.1	61.7 (3)	8.5
	France	120.8	6.8	3,643	7.5	29.4	4.1
	Sub-Total	1,563.7	88.3	42,310	87.2	660.7	91.2
Medium Industrial R&D Effort	Italy	40.3	2.3	996	2.1	13.7	1.9
	Netherlands	28.2	1.6	938	1.9	4.6 (6)	0.6
	Sweden	23.5	1.3	848	1.8	8.1	1.1
	Canada	21.5	1.2	681	1.4	9.0	1.2
	Belgium	18.3	1.0	531	1.1	2.7 (6)	0.4
	Switzerland	17.5 (5)	1.0	917	1.9	10.5 (7)	1.4
	Australia (1973)	16.1	0.9	(440)	(0.9)	4.9	0.8
	Sub-Total	165.4	9.3	5,351	11.0	53.5	7.4
Small Industrial R&D Effort	Spain (1974)	11.1	0.6	158	0.3	2.6	0.4
	Austria	8.3	0.5	(157)	(0.3)	1.9	0.3
	Denmark	6.1	0.3	166	0.3	1.5 (6)	0.2
	Finland	6.1	0.3	131	0.3	1.7 (6)	0.2
	Norway	5.8	0.3	183	0.4	2.1 (6)	0.3
	New Zealand	1.6 (4)	0.1	(26)	0.1	..	..
	Ireland	1.1	0.1	20	0.0	0.4	0.1
	Portugal (1976)	1.1	0.1	9	0.0	0.1	0.0
	Greece (estimate)	(1.0)	0.1	9	0.0	..	..
	Iceland	0.0	0.0	0.0	0.0	0.0	0.0
	Sub-Total	42.3	2.4	859	1.8	10.3	1.4
	GRAND TOTAL	1,771.4	100.0	48,520	100.0	724.5	100.0
	of which EEC	581.3	32.8	15,114	31.2	186.1	25.6

(1) At current exchange rates
(2) OECD estimate
(3) Not in full-time equivalent
(4) 1972 not in full-time equivalent
(5) Not RSE but persons with university qualifications
(6) Not RSE but persons with university and equivalent technical qualifications

Table 3. Macro-Data: GNP (Current Prices)

Country	1950	1955	1960	1965	1970	1975	1978
France (billions of Francs)	123.0	172.2	298.5	487.3	786.8	1,455.2	2.135.1
Germany (billions of Deutche Mark)	119.5	180.4	303.0	458.2	679.0	1,033.9	1,282.6
Japan (billions of Yen)	--	8,622	15,487	32,070	73,503	148,798	206,303
United Kingdom (billions of Pounds Sterling)	13.3	19.36	25.73	36.04	51.53	123.80	161.17
United States (billions of U.S. Dollars)	286.3	506.0	688.1	982.4	1,528.8	1,528.8	2,127.6

Source: IMB, International Financial Statistics Yearbook, 1979.

Table 4. Balance of Trade in Current Prices *

Country	1950	1955	1960	1965	1970	1975	1978
France	10.78	17.36	33.9	50.24	100.52	227.20	357.60
	---	---	--	47.60	99.67	220.44	355.04
	---	---	--	---	327	1,509	1,560
Germany	8.36	25.72	47.95	71.65	125.28	221.59	284.91
	10.63	22.87	39.93	65.96	102.92	176.88	235.60
	---	---	2,109	1,421	5,688	17,683	25,257
Japan	298	724	1,460	3,043	6,954	16,572	20,569
	290	741	1,347	2,423	5,664	15,172	15,122
	---	---	271	1,901	3,963	5,030	25,594
United Kingdom	2,259	3,024	3,789	4,932	8,170	20,111	37,363
	2,350	3,499	4,194	5,213	8,285	22,825	38,508
	---	- 876	- 1,142	- 615	108	- 6,585	- 1,760
United States	---	14,302	19,651	26,751	42,659	107,130	143,574
	8,984	11,564	15,071	21,428	39,952	96,116	172,024
	---	2,748	4,892	4,951	2,603	9,051	- 34,190

* (IMF) reported: exports (millions of own currency as above)
imports (millions of own currency as above)
trade balance of f.o.b. (millions of U.S. dollars)

Table 5. Industrial Production Growth in Developing Countries, 1971-1977

(Percentage change from corresponding period of preceding year)

Component and period	Developing countries a/	Western hemisphere	Asia a/
Chemistry b/			
Average, 1971-1977	6.9	6.5	8.1
1975	1.0	0.9	1.4
1976	8.8	6.2	11.9
1977	6.9	5.9	8.5
First quarter	5.3	3.1	8.4
Second quarter	5.8	6.0	6.2
Third quarter	7.1	8.0	6.5
Fourth quarter	9.2	6.1	12.4
Mining			
Average, 1971-1977	4.3	1.0	7.3
1975	-8.9	-6.6	-9.3
1976	9.8	2.3	12.4
1977	6.8	3.6	8.4
First quarter	6.4	2.6	8.9
Second quarter	4.7	3.1	6.2
Third quarter	3.1	4.4	2.7
Fourth quarter	12.8	4.0	15.2
Manufacturing			
Average, 1971-1977	7.4	7.0	8.1
1975	3.2	1.2	6.3
1976	8.4	6.6	11.7
1977	6.8	6.0	8.2
First quarter	4.9	2.9	8.2
Second quarter	5.8	6.1	5.7
Third quarter	7.9	8.2	7.6
Fourth quarter	8.2	6.3	11.3

Source: Centre for Development Planning, Projections and Policies of the United Nations Secretariat, based on United Nations, *Monthly Bulletin of Statistics*.

a/ Israel has been included with the developed market economies and Turkey with the developing countries.

b/ ISIC 2-4

Table 6. Balance of Payments Summary for Developing Countries, 1971-1977 a/
(Billions of Dollars)

Country group and year	Balance of trade b/	Balance of services and private transfers c/	Balance on current account	Net capital flow d/	Change in reserves
Developing countries					
1974	55.4	-16.3	37.9	-2.9	35.0
1975	12.4	-15.9	-3.5	11.5	8.0
1976	36.9	-21.7	15.2	4.1	19.3
1977	35.8	...	...	...	21.5
Oil-exporting developing countries					
1974	87.0	-19.6	67.4	-34.7	32.7
1975	56.3	-21.6	34.7	-25.2	9.5
1976	65.4	-24.4	41.0	-32.6	8.4
1977	58.7	...	...	...	12.4
Non-oil-exporting developing countries					
1974	-32.8	3.3	-29.5	31.8	2.3
1975	-43.9	5.7	-38.2	36.7	-1.5
1976	-28.5	2.7	-25.8	36.7	10.9
1977	-22.8	...	...	...	9.1
Western hemisphere					
1974	14.2	1.1	-13.1	12.5	-0.6
1975	-16.6	0.3	-16.3	14.2	-2.1
1976	-12.4	1.1	-11.2	15.9	4.7
1977	-5.8	-1.4	-7.2 e/	10.0	2.8
Africa					
1974	-1.9	-2.0	-3.9	4.2	0.3
1975	-7.4	-0.6	-8.0	7.7	-0.3
1976	-5.7	-1.2	-6.9	7.3	0.4
1977	-4.2	...	...	...	0.8
West Asia					
1974	-5.6	2.7	-2.9	3.4	0.5
1975	-6.8	2.8	-4.0	4.5	0.5
1976	-6.1	2.1	-4.0	4.5	0.5
1977	-8.2	...	...	...	1.2
South and East Asia					
1974	-11.1	1.5	-9.6	11.7	2.1
1975	-13.0	3.1	-9.9	10.4	0.5
1976	-4.4	0.7	-3.7	9.2	5.5
1977	-4.5	...	...	...	4.2

(Source and footnotes on following page.)

(Source and footnotes to Table 6)

Source: Centre for Development Planning, Projections and Policies of the United Nations Secretariat, based on International Monetary Fund, Annual Report, 1977 and International Financial Statistics (Washington, DC)

a/ Data for 1977 are preliminary.

b/ Exports, f.o.b. minus imports, c.i.f.

c/ The balance of services and private transfers is computed as the difference between the trade balance and the current account balance

d/ Net capital inflow is computed residually as the difference between the balance financed by transaction in reserve assets and the current account balance. It includes government transfers, reported capital movement and errors and omissions.

e/ Preliminary estimates by the Economic Commission for Latin America.

Table 7. Rate of Productivity Growth, 1960-1979.

Country	Annual Percent Change 1960-66	1967-73	1973-79
Canada	4.3	4.9	2.8
Japan	8.5	10.0	4.2
Italy	7.3	6.6	3.3
West Germany	5.8	5.0	5.0
France	5.4	5.7	5.1
United Kingdom	4.1	3.8	0.6
United States	4.2	2.9	2.1

Source: Newsweek, September 8, 1980. P. 52.

Table 8. Foreign Manufacturing Subsidiaries Established by 180 Multinational Enterprises, by Principal Activity.

	Period of entry							
	Before 1946	1946-1950	1951-1955	1956-1960	1961-1965	1966-1970	1971-1975	total Total
Subsidiaries of 61 technology-intensive parents								
Total number	250	75	150	298	518	747	627	2,665
Technology-intensive	184	56	120	207	331	441	383	1,722
Other	66	19	30	91	187	306	244	943
Technology-intensive as % of total	73.6¢	74.7%	80.0%	69.5%	63.9%	59.0%	61.1%	64.6%
Subsidiaries of 119 other parents								
Total number	498	150	259	642	1,076	1,437	1,029	5,091
Technology - intensive	49	10	35	91	227	270	230	912
Other	449	140	224	551	849	1,167	799	4,179
Technology-intensive as % of total	9.8%	6.7%	13.5%	14.1%	21.1%	18.8%	22.3%	17.9%
Subsidiaries of all 180 parents								
Total number	748	225	409	940	1,594	2,184	1,656	7,756
Technology-intensive	233	66	155	298	558	711	613	2,634
Other	515	159	254	642	1,036	1,473	1,043	5,122
Technology-intensive as % of total	31.1%	29.3%	37.9%	31.7%	35.0%	32.6%	37.0%	34.0%

Table 9. Foreign Manufacturing Subsidiaries Withdrawn by 180 Multinational Enterprises, by Principal Activity

	Period of withdrawal				
	Before 1960	1961–1965	1966–1970	1971–1975	Total
Subsidiaries of 61 technology-intensive parents					
Total number	17	35	186	227	465
Technology-intensive	14	25	122	129	290
Other	3	10	64	98	175
Withdrawals as % of number in existence during period[a]					
Total	2.0%	2.6%	9.6%	8.9%	
Technology-intensive	2.4	2.8	9.8	8.3	
Other	1.2	2.6	9.4	10.3	
Subsidiaries of 119 other parents					
Total number	86	86	306	441	919
Technology-intensive	8	15	68	101	192
Other	78	71	238	340	727
Withdrawals as % of number in existence during period					
Total	5.5%	3.4%	8.0%	9.7%	
Technology-intensive	4.2	3.6	10.2	12.2	
Other	5.8	3.3	7.6	9.1	
Total	103	121	492	668	1,439

Table 10. World Book Production (1976)*

MAJOR AREAS	NUMBER OF TITLES in thousand	per inhabitants	PERCENTAGE DISTRIBUTION production	population
WORLD	591	186	100	100
Africa (including Arab States)	11	26	1.9	13.0
Asia** (including Arab States	100	70	16.7	45.2
North America	91	382	15.2	7.5
Latin America	31	93	5.2	10.5
Europe	269	565	45.1	15.0
Oceania	5	227	0.8	0.7
USSR	84	326	14.1	8.1
Arab States	6	40	1.0	4.5
Developed countries	491	434	83.1	35.6
Developing countries	100	49	16.9	64.4

* Source: Unesco Statistical Yearbook (1976).
** Not including China and DPR of Korea.

Table 11. World Production of Scientific and Technical Periodicals (1960-1980)

Year of Publication	No. of S&T Periodicals Worldwide[1]	No. of S&T Periodicals U.S.[2]	No. of S&T Journals U.S.[3]
1960	18,800	6,335	2,815
1961	23,600	6,465	2,830
1962	23,100	6,614	2,854
1963	26,462	6,780	2,897
1964	25,573	6,950	2,947
1965	26,235	7,120	3,010
1966	30,110	7,290	3,109
1967	34,594	7,500	3,221
1968	37,182	7,670	3,349
1969	39,674	7,830	3,505
1970	40,431	7,920	3,656
1971	41,930	8,020	3,804
1972	44,676	8,170	3,935
1973	47,657	8,330	4,078
1974	49,440	8,460[3]	4,164
1975	49,373	8,414[3]	4,175
PROJECTIONS			
1976	52,302	8,765	4,309
1977	54,682	8,915	4,447
1978	56,875	9,065	4,593
1979	59,003	9,214	4,743
1980	61,110	9,364	4,901
PERCENT CHANGE			
1960-65	40	12	7
1965-70	54	11	21
1970-75	22	6	14
1975-80	24	11	17

SOURCES:

[1]1961: Gottschalk, C. M. and Desmond, W. F., "Worldwide Census of Science and Technology Serials." American Documentation, 14:3 (July 1963).

1963-1974: Line, Maurice B. and Wood, D.N., "The Effect of a Large-Scale Photocopying Service on Journal Sales." Journal of Documentation (scheduled for publication).

[2]1971: Davey, J.S. and Smith, E.S., "The Overseas Services of the British Library Lending Division." Unesco Bulletin 29:5 (September-October 1975).

[3]King Research, Inc.

Table 12. World Production of Patents (1974)

Selected Countries	Applications	Patents
Argentina	5 389	4 514
Australia	15 950	12 828
Belgium	14 728	14 652
Brazil	10 936	--
Canada	27 956	21 287
Czechoslovakia	2 558	1 701
Denmark	6 924	2 429
France	43 633	24 725
German Democratic Republic	7 587	7 971
Germany (Federal Republic of)	63 545	20 539
Japan	149 319	39 626
Netherlands	17 062	3 386
Poland	9 230	6 644
Romania	2 513	2 495
Soviet Union	100 754	41 199
Sweden	16 393	9 426
Switzerland	17 429	12 970
United Kingdom	56 250	37 808
United States	102 538	76 275

Source: World Intellectual Property Organization. Industrial Property Statistics 1974. Geneva, WIPO, 1975.

Table 13. World Abstracting and Indexing Organizations, 1960-1975

Type of Organization	1960[1]	1963[2]	1969[3]	1975[4]
U.S. Science & Technology	500	365	-	330
World Science & Technology	-	1,855	816*	670
All Fields	-	-	996*	2,100

*Indexing services not counted.

SOURCES:

[1]National Federation of Abstracting and Indexing Services, A Guide to U.S. Indexing and Abstracting Services in Science and Technology, 1960.

[2]A Guide to the World's Abstracting and Indexing Services in Science and Technology (Report No. 102), 1963.

[3]Abstracting Services: Volume 1, Science, Technology, Medicine, Agriculture; Volume 2, Social Sciences and Humanities, Federation Internationale de Documentation (The Hague), 1969.

[4]NFAIS estimate.

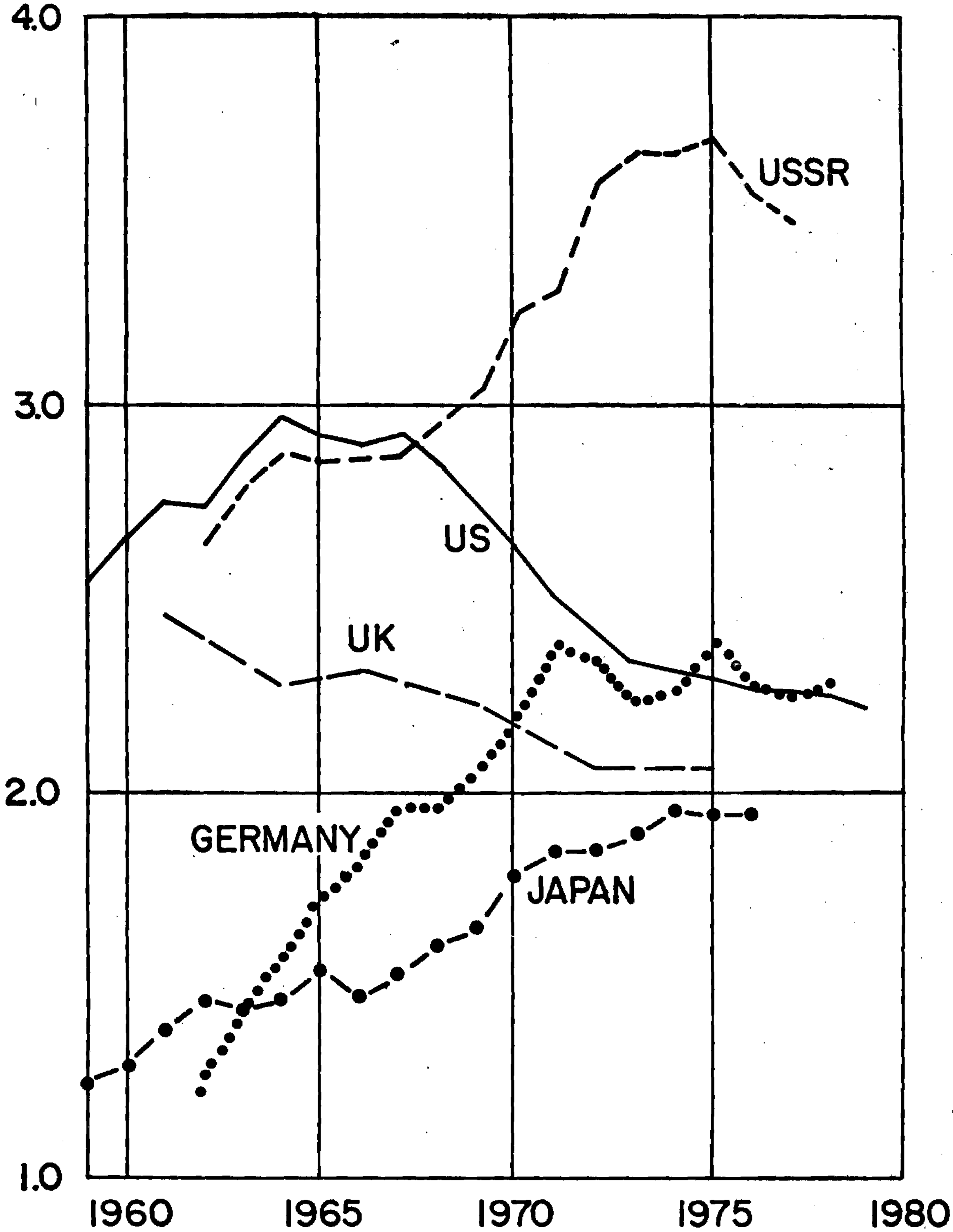

Figure 1. R&D Expenditures as Percent of GNP.
Source: National Science Foundation.

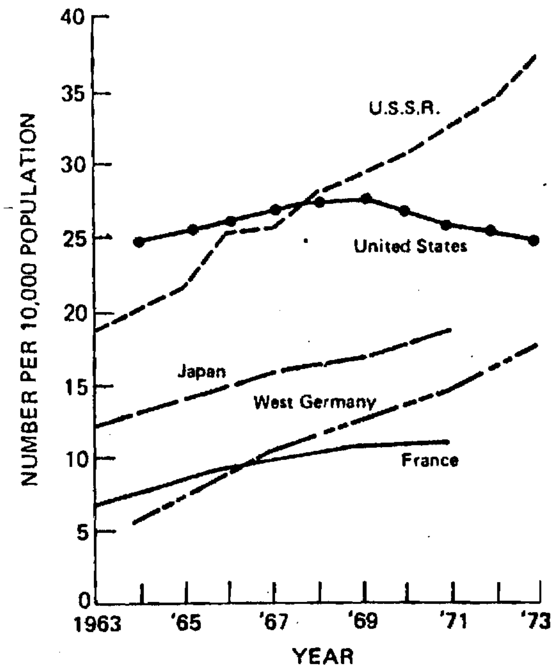

Figure 2. Scientists and engineers engaged in R&D per 10,000, 1963-1973.

Includes all scientists and engineers (full-time equivalent basis). Data for the United Kingdom are not available.

Source: National Science Board. Science Indicators 1974. Washington, D.C.; National Science Foundation, 1974

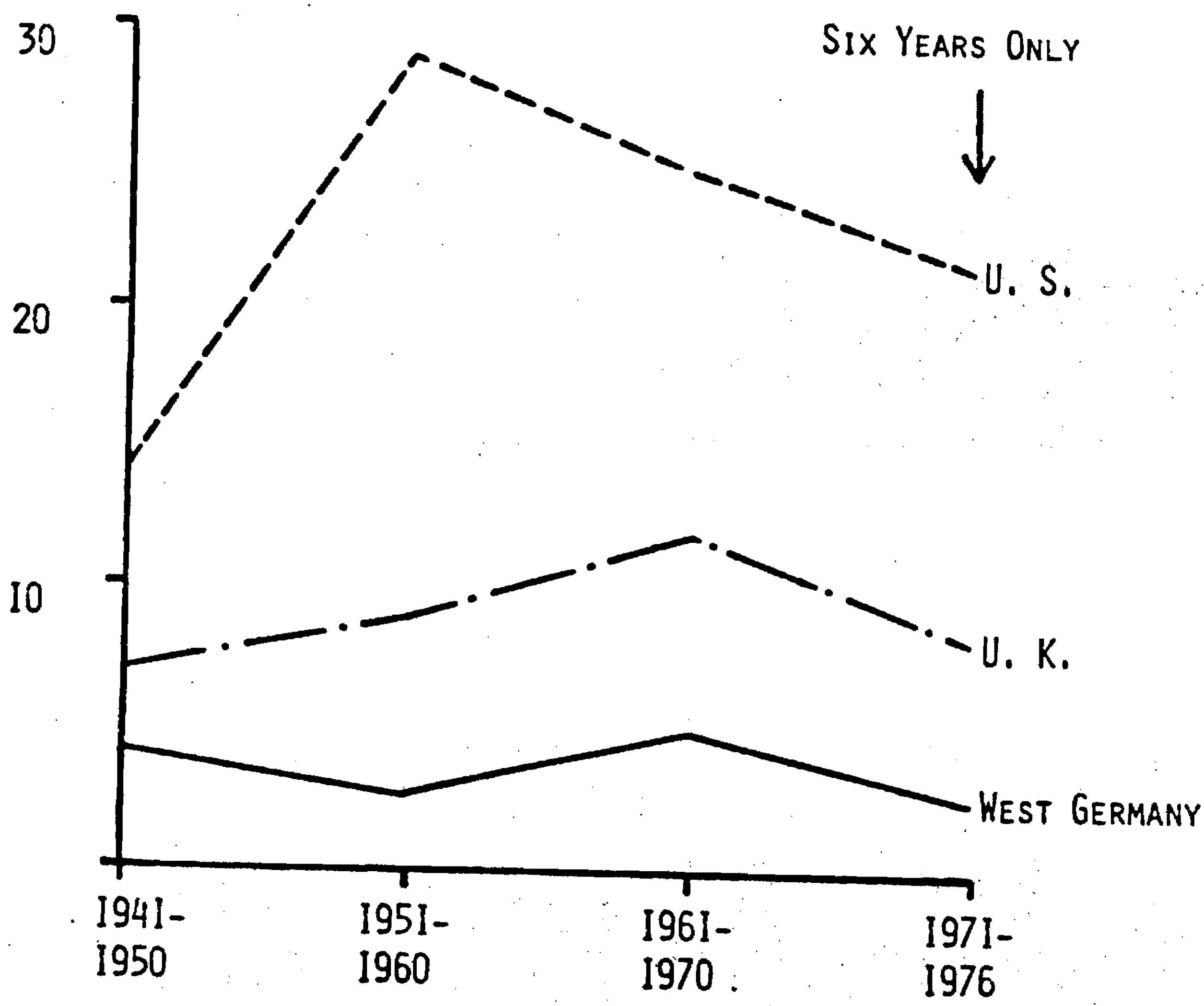

Figure 3. Number of Nobel Prize Awards for U.S.; U.K.; West Germany; Japan, per Ten-Year Periods.

Note: Japan had one Nobel Laureate in 30 years.

Source: National Science Board. Science Indicators 1976. National Science Foundation, 1977. P. 196.

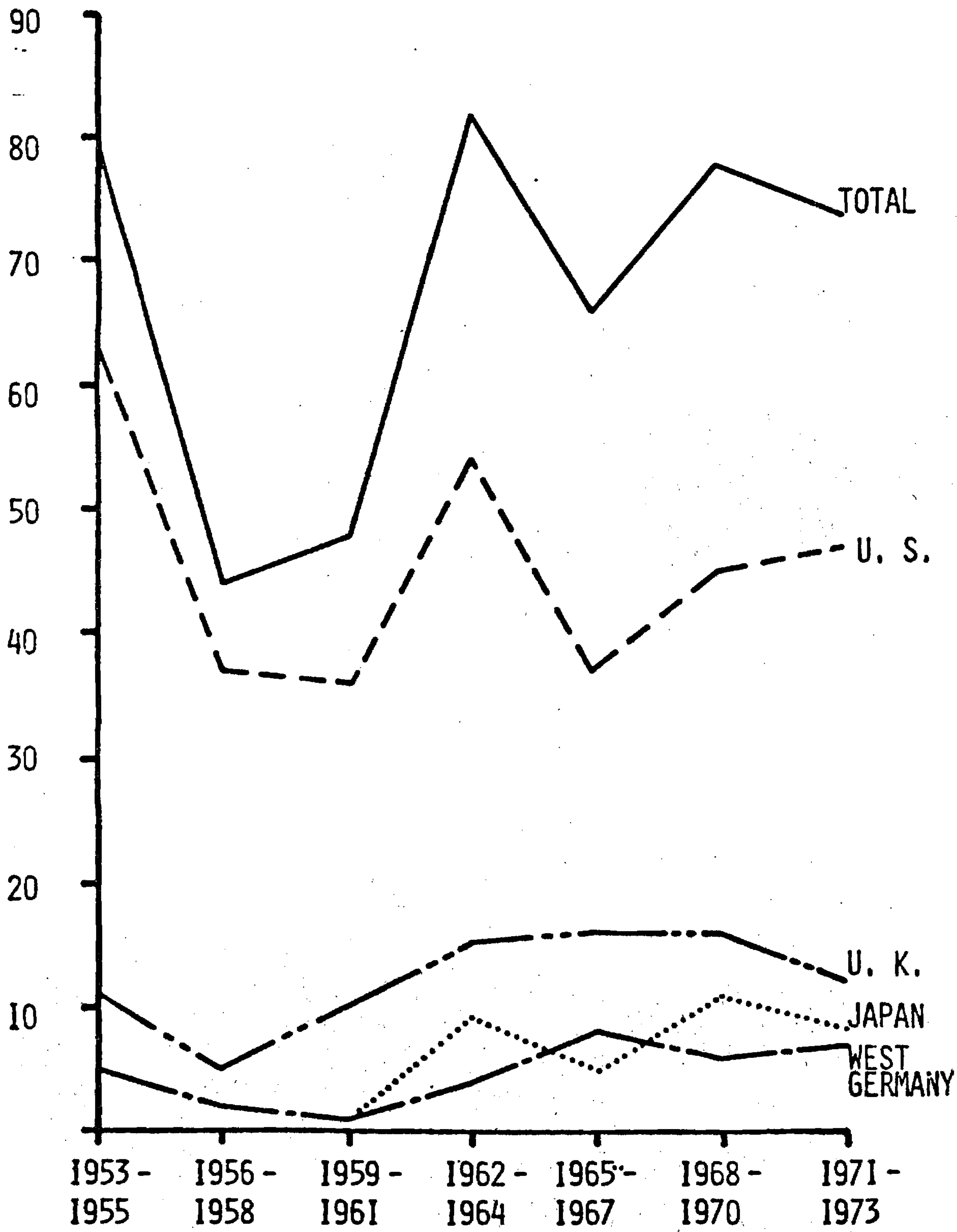

Figure 4. Major Technical Innovations for U.S., U.K., Japan, West Germany per Three-Year Periods (1953-1973).

Source: National Science Board. Science Indicators 1976. Washington, D.C., National Science Foundation, 1976. P. 199.

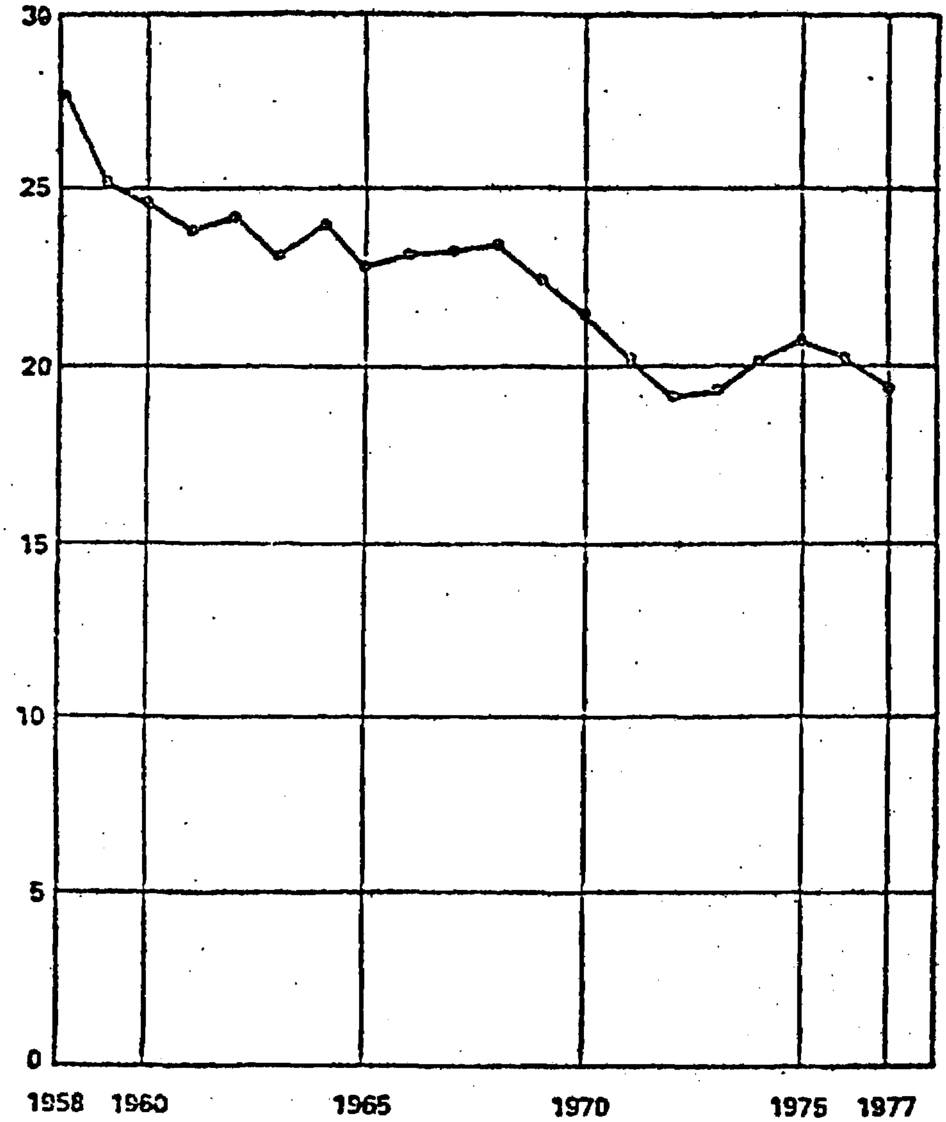

Figure 5. U.S. Share of World Exports of Manufactured Goods, 1958-77, in Percent.

Source: Commerce America, June 19, 1978, p. 9.

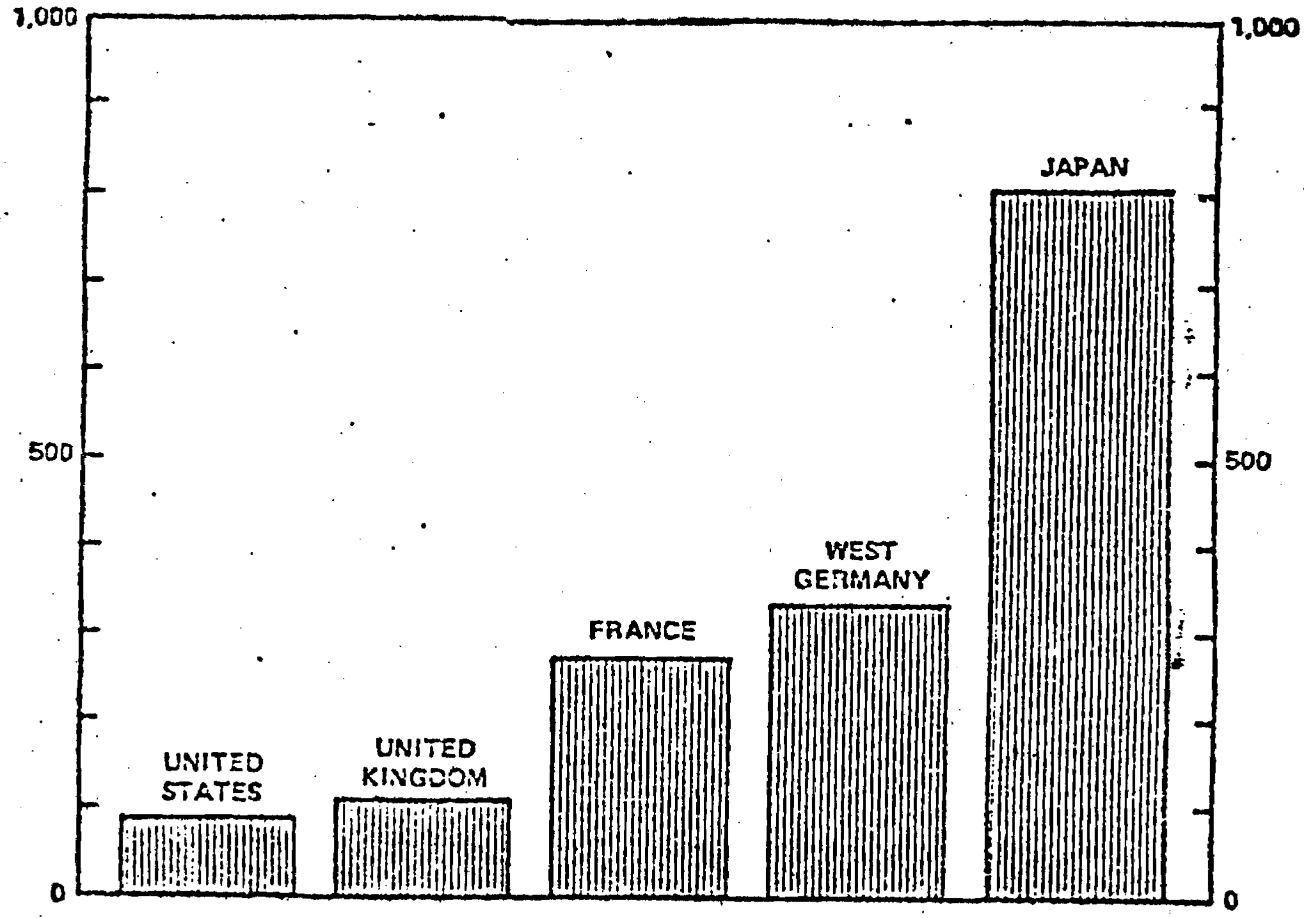

Figure 6. Output Per Hour in Manufacturing (Increase in Percent, 1950-77).

Source: "Output per Hourly Compensation, and Unit Labor Costs in Manufacturing, Eleven Countries, 1950-77." Bureau of Labor Statistics, U.S. Department of Labor, May 4, 1978.

APPENDIX

INTERNATIONAL INFORMATION FLOWS: SELECTED CONTROL MECHANISMS

The preceding study described some of the major socioeconomic and political consequences of international exchanges of scientific and technological information. To our knowledge, the comparative effects of the outflow and inflow of scientific and technological information have not been assessed with regard to their impact on the productivity, employment, economic growth, and foreign exchange earnings of the U.S. or other countries, nor on other consequences. We may, however, attempt to consider the major mechanisms which can determine, at least in part, the extent of these consequences. The mechanisms briefly considered in this Appendix are 1) direct U.S. investment in foreign manufacturing facilities, 2) sales of U.S. technology-embodying products abroad, 3) international license trade, 4) tax policies, 5) foreign government regulations, 6) applications of information technology, and 7) intellectual property rights. Another major mechanism, direct transfer of U.S. information through movement of data, consultants and employees, is the subject of the study preceding this Appendix.

1. Direct Investment in Foreign Manufacturing Subsidiaries.

The distinguishing economic characteristic of this channel of transfer, manufacturing subsidiaries and joint ventures for manufacturing, is that the U.S. firm invests management effort as well as information and money in the enterprise with the expectation of receiving some part of the enterprise's proceeds. There is a considerable variety of the amount of technical training given to host country employees.

Let us examine several indicators of such transferred information and its value.

- First, the extent of the manufacturing operations established locally and performed by locals varies. The U.S. firm may fabricate components and assemble them while the local plant may only assemble components. Assembly has been the first operation to be transferred abroad in several industries: for example, automobiles,[57] semiconductors,[58] and clothing. If local industries did develop more, then either other operations were transferred gradually or local suppliers developed to make substitutes for imported components. Many suggest that assembly is transferred abroad because it uses a lot of unskilled labor: relatively low wages and low skill requirements make assembly operations easy to transfer. In other words, the low technical information content of assembly operations makes them easy to move wherever wages are lowest. While there are some important questions of job displacement associated with technology transfer in assembly operations, low factor costs and tariff barriers, rather than technical information, seem to be the causes of the opposition that arises from time to time to this sort of technology transfer.

At the other extreme, a U.S. company might build a manufacturing facility including all operations done at comparable U.S. plants and train locals to use and to improve the process and products. In this case the country might have its first capability in a high technology industry. This would also entail the employees' abilities to improve the process and begin competing companies or join extant competitors.

- Second, the market and technology environments of the host country vary tremendously. Assume that the country does not possess the technological information brought in by the U.S. firm and that the country possesses a group of well-trained professionals in closely related technologies and a good group (i.e., able and rich) of potential factor suppliers. Then the U.S. firm could have three important effects on the local economy: on its suppliers, potential competitors, and customers.

  All these will adapt to the U.S. firm. Suppliers may learn process control as many in the U.K did from the first U.S. semiconductor manufacturers there. Suppliers may learn to make new products. Both of these make the local suppliers better able to sell to other local firms and to the world market. Industrial customers learn how to incorporate the new (or perhaps much cheaper) products. Industrial customers would -- as a result -- be both enlarged customers and stronger competitors on the world market. Finally, potential rivals are challenged by the new, advanced U.S. firm. To the extent that they tried to meet the competition their whole local industry would become added customers for U.S. licenses and products and also more viable competitors on the world markets.

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[56] Baranson, Jack. Automotive Industries in Developing Countries. Baltimore, Md., the Johns Hopkins Press, 1969.

[57] Tilton, John E. International Diffusion of Technology: The Case of Semiconductors. Washington, D.C., The Brookings Institution, 1971.

At the other extreme, if the country has no local technology base, no potential suppliers, and very unsophisticated potential customers, then the U.S. plant will have to import factors of production and export finished products. Its presence and technical information may end up in such situations stimulating very little new business in the country over and above its own.

In sum, the local economy is strengthened by the transfer of technical information as: a) the local operations have more technical content; b) the local employees are able to operate and to improve a larger extent of the operations; c) the local economy has good potential suppliers who can adapt to the U.S. plants' factor needs more quickly and better; d) the local economy has good potential customers for the U.S. plant who can find new applications for U.S. firms' products; and e) the local economy has more and better potential competitors and imitators of the U.S. plant who can themselves learn and both buy and sell more products of the sort the U.S. makes (good potential imitators are probably firms with strong technical people and large financial resources).

2. U.S. Foreign Sales of High Technology Goods

The call for more control of the export of U.S. technological (non-military) information is based on the argument that such exports have contributed to the decline of this country's competitiveness in world economic markets, and that they not only erode the base of U.S. innovation but also have a negative impact on the numbers and skills of labor employed.

A contrasting view, acknowledging that some controls are relevant in the case of strategic (military) technology, holds that controls are ineffective or even counterproductive. First, it is extremely difficult to reach agreement between industry and government on what kinds of technological information are commercially strategic; and the tracking of changes in technologies is not easily performed. Second, it is said that until the question of the cost of losing markets versus the gains from technology lead times is resolved, control over export of U.S. information will remain a contentious subject. Third, controls on U.S. information export are not likely to remain unilateral for long, and our action might trigger a response whose effect might be to limit U.S. access to foreign information. Fourth, it is widely believed to be in the U.S. national interest to facilitate technological progress; that has been one of the chief aims of American policy in less developed countries. Finally, there are constitutional questions about the right of the government in a free society to control the flow of non-strategic information.

Clearly, foreign sales of high-technology goods will have the largest effect on foreign economies' strength when there is no other source of the high technology products. If U.S. firms are the only source of high technology products and they are ready to sell, their sale may allow foreign firms to develop their own high-technology products and processes using the U.S. goods. But where the U.S. is not the only source and/or is reluctant to sell the goods, firms in other countries may be stimulated to develop their own capabilities and thus compete with the U.S. firms. If firms from many nations sell substitute products embodying the same technical capabilities, U.S. foreign sales have very little impact on the technology embodied in foreign economies.

3. International License Trade

This mechanism signifies the buying and selling, across national frontiers, of technical and industrial licenses. In contrast to the trade in goods, which involves the exchange of material products, the transfer of licenses concerns legally protected property rights (patents, designs, and copyrights).

There is a significant amount of foreign licensing of patents held by U.S.-based firms. Patents themselves entail the rights to use a process or product, not the know-how. Technology-licensing, on the other hand, may be an important source of competitive advantage to a recipient firm. Technology licensing is know-how transfer and it entails getting another firms' employees to run the recipient firms' operations. The sales of licenses abroad fall into two categories: production under license by independent licensees -- i.e., firms which through their capital are linked with the licensing concern; and production by foreign subsidiaries of U.S. firms.

A 1973 survey of trends in international licensing trade noted that the U.S. has played a dominant part in the world as a licensor, and that about three-fourths of the total revenue received during 1966-1972 by the U.S. for granting licenses abroad came from a few subsidiaries operating abroad, whereas the remaining quarter originated from the numerous independent foreign firms.[59]

In contrast, foreign technology inflow to the U.S. via licensing has unimpressed another study which noted that "despite the general increase in technological activity outside the United States, the pattern of U.S. receipt and payments for patents, manufacturing rights, and license fees has not reflected any corresponding increase in the utilization of foreign technology," and citing Science Indicators 1972, it concluded that "in fact, the opposite trend is discernible, because receipts from foreign countries for U.S. technology experienced a much faster rise than U.S. payments for foreign technology. . . . The figures indicate that the United States is continuing to fuel technological development in foreign countries with little return flow being evident.[60]

4. U.S. Tax Policies

Tax policies appar to have considerable effect on the generation of knowledge (through R & D) as well as on its transfer abroad (through direct investment overseas). Okubo[61] cites a recent example -- a U.S. Treasury Regulation (1.861-8) which requires firms to allocate R & D expenditures incurred in the U.S. among foreign sources of income because the income may be attributed to domestic R & D; the regulation encourages the location of R & D facilities abroad, and thus diminishes the amount of R & D conducted

[59] Wolf, A. "Trends in the International License Trade." Intereconomics 5:150-153 (1973).

[60] Gee, Sherman, "Foreign Technology and the United States Economy," Science 187:622-626 (February 21, 1975).

[61] Okubo, S. "Industrial Innovation and U.S. Policy: International Transactions." Unpublished paper prepared for the Domestic Policy Review, 1979.

in the U.S. (The Department of the Treasury has recently conducted an analysis of the effects of this regulation, and a revised bill has been submitted.) Another example is the weakening U.S. position in global service markets, said to be due in part to the fact that the nation's tax on the earnings of American working abroad "boosts their costs so much that they cannot bid competitively."[62]

To all appearances little or no consideration has been given to tax incentives favoring information services to developing countries.

5. Foreign Government Actions

Foreign governments and international organizations exercise increasing influence on international flows of scientific and technical information through a host of approaches that range from regulation to cooperative strategies. Examples of some of these approaches follow:

a) Tariffs. The overall cost of Euronet (European computer network) information service is substantially lower than that of the U.S. because of the special telecommunications tariffs from the member countries of the European Economic Community.[63] European ministries of posts, telephones, and telegraphs (government controlled monopolies) now price their facilities at rates that are prohibitive for the development of private user-controlled networks; and new proposals have been put forth which threaten elimination of private lines altogether. These regulations might benefit some American information providers if they are allowed and are willing to put their databases on Euronet; and by the same token inhibit the use of American databases available only via rival networks.

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[62]"The U.S. Lead in Service Exports is Under Siege," Business Week, September 15, 1980, p. 70.

[63]Barwise, E., The Impact on User Charges of the Extended Use of Information Services. Luxembourg, Office for Official Publications of the European communities, 1979.

b) Government subsidies. Foreign governments appear to be willing to provide assistance to private information suppliers to generate internationally competitive products and services. The Commission of the European Communities has launched a major initiative aimed at corraling one third of the world telematics market by 1990, with emphasis on the information supply industry. "The challenge in this sector is to create at least 500 new databanks, databases and value-added services" by the middle of the 1980s. The French alone have set an objective of 50 new databases by 1983 [covering] not only science and technology but also and even more socioeconomic fields, statistical data and models, and company information, where U.S. services presently supply 90% of the world demand." Whereas the effort is to proceed via private enterprise, "governments and the Community institutions should concentrate . . . on creating the right conditions under which many private ventures could be launched with a good chance of success."[64]

The stimulation of domestic information services by some foreign governments worries American enterpreneurs as to their ability to compete successfully in international markets.[65]

c) Non-tariff barriers. Many countries are said to have begun imposing more and more non-tariff barriers against foreign service companies including discriminatory taxes and licensing requirements, quotas on foreign advertizing, restrictions on repatriation of royalties, fees and other earnings, and preferential shipping agreements.[66]

The new European Patent Convention has a rule on "absolute novelty" which stipulates that "technical reports to government in free countries

[64] "Telematics Challenge," Euronet DIANE News 18:5 (March 1980).

[65] Brenner, E.H., "Euronet and Its Effects on the U.S. Information Market." Journal of the American Society for Information Science 30:5-8 (January 1979).

[66] "The U.S. Lead in Service Exports is Under Siege," Loc. cit., p. 70.

are considered public knowledge and become a bar to patentability." While it is difficult to estimate the extent of damage done to the U.S. interests, at least until the new European Patent Convention has been tested by U.S. companies, one possible consequence is that U.S. firms that do as required -- i.e., report to the U.S. government on work funded partly by the government -- may forfeit claims to patents in Europe. The prospect of forfeiting European patent rights may discourage entrepreneurs in the private U.S. sector from seeking public research support.

d) Cooperative strategies. International collaboration at the governmental level may determine the future of information markets even more than the regulatory practices of individual governments. The developing countries in particular have grasped the utility of this strategy, and are bracing themselves -- usually with the help of the United Nations -- to play effective roles in these markets. The UN Economic Commission for West Africa recently launched a $150 million Pan-African Documentation and Information System for Social and Economic Development, whose main databases will contain world economic data to be used on a continent-wide network of African states. Other developing countries have set up, under the patronage of the U.N. Industrial Development Organization, a databank on commercial practices of firms active in international markets. This international "better business bureau" gathers information from participating LDC governments on such aspects as comparative assessment of products, prices, contractual conditions, compliance with schedules, and many other variables. A still different example is the recent move of developing countries to declare all technologies used in their countries public after five years. This strategy lowers U.S. firms' incentives to exploit technology there, and it may consequently reduce the outflow of U.S. technological information to these countries.

6. Applications of Information Technology

Rapidly evolving information technology opens powerful new alternatives for international information transfers. In general, technological progress makes possible changes in this field because the development of new technologies and the progressive reductions in the cost/performance of available technology lower the cost of existing services and permit the introduction of economically attractive new services.

Examples of new and improved information technologies abound,[67] as do examples of their effects. Cost/performance of computer systems has improved by about 25% per year between 1950 and 1975, making it possible to provide relatively powerful applications (such as bibliographic retrieval) on small stand-alone systems costing $20,000. New technologies are reducing the communications costs at a rate of about 11% per year; it is now economically feasible to have a small rooftop antenna linked on one side to overseas databases (with the cost of transmission being independent of distance), and on the other end to a local network connecting large numbers of terminals. These two examples alone indicate the different possibilities in restructuring information services -- one alternative being stand-alone, inexpensive systems (having low-cost, high-capacity storage media such as videodisks and containing full text or huge central archives), another being highly communications oriented networks.

The trend toward the electronic generation, storage, transmission and exploitation of information -- whether it be in the form of archival records or personal knowledge communicated in real time -- is beginning to change profoundly the global situation regarding the availability, accessibility, and distribution of this resource. The nature of these changes and of their consequences has so far been largely in the real of speculation, and it should be studied by the U.S. with great urgency. While the growing abundance of communications leads to plausible inferences regarding more intensive and freer flows of information,[68] electronic information storage simultaneously provides opportunities for regulating access to and diffusion of information. Such opportunities are pertinent to the management of proprietary information, and to selective distribution of information to limited user groups.

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[67] See, for example, Branscomb, L.M., "Computing and Communications -- A Perspective of the Evolving Environment," IBM Systems Journal 18(2):189-201 (1979).

[68] Cf., De Sola Pool, I., Op. cit.

A major significance of modern information technology in this area thus lies in its ability to expand and contract communication communities, communication channels, as well as the volume of traffic in each channel; and to do so with a very fine degree of resolution. In view of this immensely powerful ability it is absolutely imperative that the United States understands better the value, functions, and use of the information resource, so that it can exploit this ability judiciously.

7. Intellectual Property Rights

The international flow of information and ideas of technological value is significantly influenced by the national and international protections afforded the forms through which the information or ideas are conveyed. Publicly available information *per se* is said to be free; but once information or an idea is embodied in a tangible form, either as a work of original authorship or as a device, process or procedure that demonstrates unambiguously an original idea, the creator of the form, be he author or inventor, may have a right to claim ownership of the form and, in the case of some ideas, ownership of the idea itself. For practical purposes, under U.S. law, the creator of the form controls, to a great degree, the dissemination of the information or idea contained in the form; and he may sell, transfer or license any of the rights so protected. So-called intellectual property rights -- copyright for forms that are works of original authorship, and patent rights for forms that embody novel, non-obvious ideas in devices, processes or procedures -- are therefore important mechanisms affecting the international flow of information and ideas; trade secrets -- that is, proprietary information or ideas for which patent or copyright protection is either not available or not desired -- play perhaps an even more important role.

The exclusive rights, copyrights and patents given to the creator are meant to encourage creation and dissemination of information, ideas and new technologies. In some countries, intellectual property rights are viewed as a "natural" right: that is, an individual has an inherent right to benefit from the fruits of his labors. However, even in countries that do not subscribe to this "natural" right philosophy, a more pragmatic principle generally prevails: rights are protected to provide an incentive (usually economic) to create and thus to promote a nation's cultural, technological advancement. The nature, level, and duration of the protections afforded different kinds of intellectual property under the laws of most countries are thus generally based on a desire to encourage individual creative incentive and commercial initiative in the interest of furthering national cultural and technological advancement.

International conventions dealing with intellectual property reflect a similar philosophy: the flow of ideas and information across national boundaries is encouraged to the extent, as determined by the level of protection, that the copyrights and patents of member nations are protected. In the simplest of terms, a market for the results of creative endeavors will be developed and exploited if the return for the creator will be profitable; the possibility of a much larger international market, even if it is a distant possibility, will increase individual creative incentive and commercial endeavors within each nation; and each nation will benefit from the flow of new information and ideas from other nations.

In practice, however, the vastly different cultural and technological levels of development that exist among countries, the race for competitive advantage, and the enormous complexity of the laws governing international trade and international protection of intellectual property make the application of simple principles very difficult. As a result, the traditional forms of protecting intellectual property -- the patent and the copyright -- are being weakened, with very substantial consequences. Creative individuals for whom the patent no longer offers prompt and reasonably strong assurance of competitive advantage report to other practices, such as keeping trade secrets. When some of the world's most important disseminators of scientific and technical information (such as the British Lending Library Division) do not recognize that copyright protection is essential to the initial creation and timely dissemination of works that embody this information, they may affect the economic viability of small publishers of particularly scientific information. The impacts on the generation and communication of scientific and technological information are nearly incalculable.