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["White Paper on Science and Technology 1991--Development of Globalization of Scientific and Technological Activities and Issues Japan Is Encountering" by the Science and Technology Agency. This paper is an "informal summary" and was prepared in Sep 91 in cooperation with the Foreign Press Center]

CONTENTS

Foreword

In these days, we often hear theories pertaining to "change of paradigms". Paradigm generally means a "framework", and the fact that questions have arisen concerning paradigm or framework eloquently shows that science and technology are facing a qualitative turning point.

Because our economic, scientific and technological activities have rapidly expanded to reach global scale, we are compelled to realize that our earth is indeed not infinite but limited. The limitation is becoming more and more apparent in many areas such as resources, energy, market and so on. We are therefore required to find ways and means of achieving a "sustainable development" in recognition of the intrinsic and fundamental limitation. This is why a great deal of expectation is placed on the future of science and technology making it possible for us to live in harmony not merely among fellow human beings but with all the life on Earth.

At this critical juncture surrounding mankind of today, this year's White Paper on Science and Technology is based on the basic theme of "Development of Globalization of scientific and technological Activities and Issues Japan is encoutering ". The primary issue to be discussed is the role Japan can play internationally in terms of the nation's scientific and technological resources. In this context, we start from a review of the globalization of scientific and technological activities in order to see in which way Japan should contribute to science and technological activities for the sake of "sustainable development" of men on the Earth.

The White Paper consists of three Parts. In Part 1, we propose to study present circumstances in the light of aforementioned basic concept. Part 2 examines international comparisons of the state of science and technology, and the present situation in Japan. Part 3 describes concnete measures which are introduced in accordance with the "General Guideline for Science and Technology Policy" which constitutes the fundamentals of policies of the Japanese Government regarding science and technology.

Part 1 Development of Globalization of Scientific and Technological Activities and Issues Japan is encountering

The Gulf War and demand for assistance to developing countries have made it a major task for Japan to define the role she should play in the international community.

Recent activities in the domain of science and technology have gone beyond the traditional framework of bilateral cooperation between two countries. Instead, international cooperation is gaining complexity as it pertains to entwined cooperative relationship involving a number of countries. At the same time, emergence of global issues has made it essential for the world to make a united effort to promote R&D in many areas of critical concern.

This White Paper comprehends these recent tendencies as "globalization of scientific and technological activities" throughout the world, making all countries ever more inter-dependent, in order to consider where Japan now stands in the new environment and how the country should play her role in the international community.

Chapter 1. Development of Globalization

Section 1. Expansion of Economic Activities Across the National Border

The recent trends in the growth of international trade, investment and security trading clearly show that economic activities are rapidly spreading out of national boundaries and more than ever national economies are becoming inter-dependent.

While this accelerating globalization is favorable to the world economy, the accompanying development of inter-dependency among the nations means national policies exert stronger impact on activities and policies of other nations. This makes it necessary for each country to seek harmonization of its interests with those of other nations.

To this end, a great deal of efforts are being made to establish a stable international order. In the field of science and technology, problems such as conflicts between different treatment of intellectual property rights and technical standards are increasing. There is a keen need that such differences in legal systems and practices be harmonized as quickly as possible.

Section 2. Globalization of Scientific and Technological Activities

1. The Position of Japan's Science and Technology in the International Community and the Development of International Exchange as Seen from Statistics

(1) International Comparison of Scientific and Technological Levels

1) Basic Research Level

A comparative survey including Japan, Europe and the United States for 12 basic research areas in materials, information/electronics, life sciences, and others shows that Japan's basic research level is slightly increasing, but there is yet a significant gap compared with the United States level. In comparison with the European countries, Japan is at a par in almost all domains while three years ago it was considered to be inferior on the whole. (Table 1)

2) Technological Level

The U.S. Department of Commerce made a survey on the competitive strength of Japan and the United States in 12 emerging technologies which were considered to be very promising in the 1990s'. The Science and Technology Agency has also made a similar survey of researchers in the same areas of technology.

While these two surveys are not perfectly matched in terms of specific technologies, they indicate the basic fact that Japan and the United States are now equal on the whole in emerging technologies' levels, and that Japan is likely to lead the United

Table 1 International Comparison in basic research

Fields	Research theme	Japan vs US		Japan vs EC	
		3 years ago	present	3 years ago	present
Life sciences	Elucidation of gene expression control mechanisms	US	US	EC	=
	Elucidation of the prpcess of growth and aging	US	US	EC	EC
	Elucidation of brain functions	US	US	EC	EC
Materials	Exploration of new phenomena on surface/interface of materials	US	US	=	=
	Research on the creation of new and highly functional materials by controlling crystalline structure	=	=	Japan	Japan
	Research on theoretical material design methods	US	US	=	=
Information/ Electrnics	Creation of highly functional devices controlled at molecular and atomic levels	US	=	Japan	Japan
	Super distributed and palallel data processing	US	US	Japan	=
	Research on the extraction of semantic information from audio-visual data	US	=	Japan	=
Ocean/Earth	Research on the global ocean circulation and the interaction between the atmosphere and the ocean through the investigation of various phenomena in the ocean	US	US	EC	=
	Research on the ecological system in the ocean	US	US	EC	=
	Research on the long-term change of air temperature through the monitoring of carbon dioxide, ozone, etc.	US	US	EC	=

Note: Country(area) named shows superior one.

Source: STA "Survey of High-tech Researchers and Engineers, 1991 "
STA "Survey of High-tech Researchers and Engineers, 1988 "

States in 1990's in these research areas except for a few domains of technology. (Table 2)

(2) International Exchange as Seen from Statistics

1) Research and Development Personnel

The trends of flow of researchers and engineers show that Japan accepts more researchers from developing countries while Japanese researchers and engineers proceeding to other advanced countries. (Figure 3)

Table 2 relative Standing in Emerging Technologies: Japan vs U.S.

Emerging Technologies	STA		DOC	
	Current status	Trends	Current status	Trends
(Life Sciences Applications)				
Biotechnology	US	↑	US	↑
Medical Divices and Diagnostics	US	↑	US	↑
(Materials)				
Advanced Materials	=	↑	Japan	↑
Superconductors	=	↑	=	↑
(Electronics, Information Systems)				
Advanced Semiconductors Devices	Japan	↔	Japan	↑
Digital Imaging Technology	=	↑	Japan	↑
High-Density Data Storage	Japan	↔	Japan	↑
High-Performance Computing	US	↑	US	↑
Optoelectronics	=	↑	Japan	↑
(Manufacturing Systems)				
Artificial Intelligence	US	↑	US	↔
Flexible Computer-Integrated Manufacturing	Japan	↔	US	↔
Sensor Technology	=	↑	US	↑

Note: Country named shows superior one.

= shows even

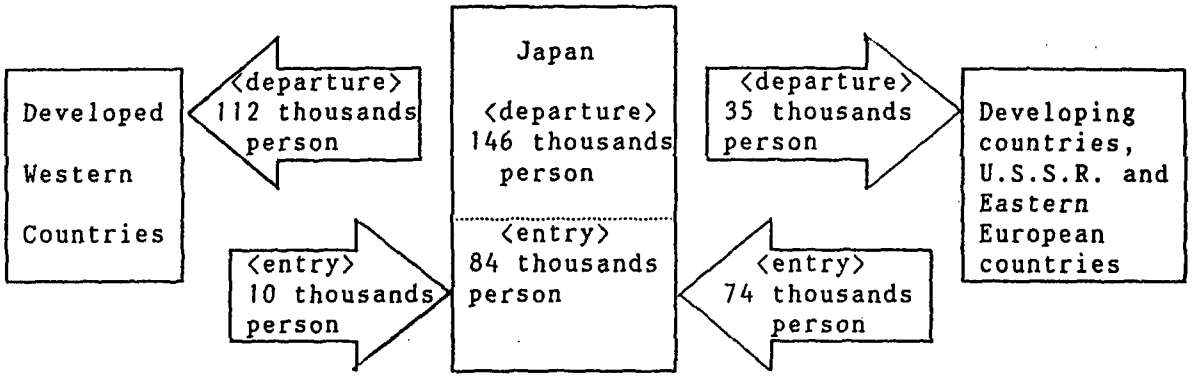
↑ Japan gaining

↔ shows two countries holding

Source: STA "Survey of High-tech Researchers and Engineers, 1991"

DOC "Emerging Technologies, Spring 1990"

Figure 3 Reseacher/engineer exchanges between Japan and other countries(1989)

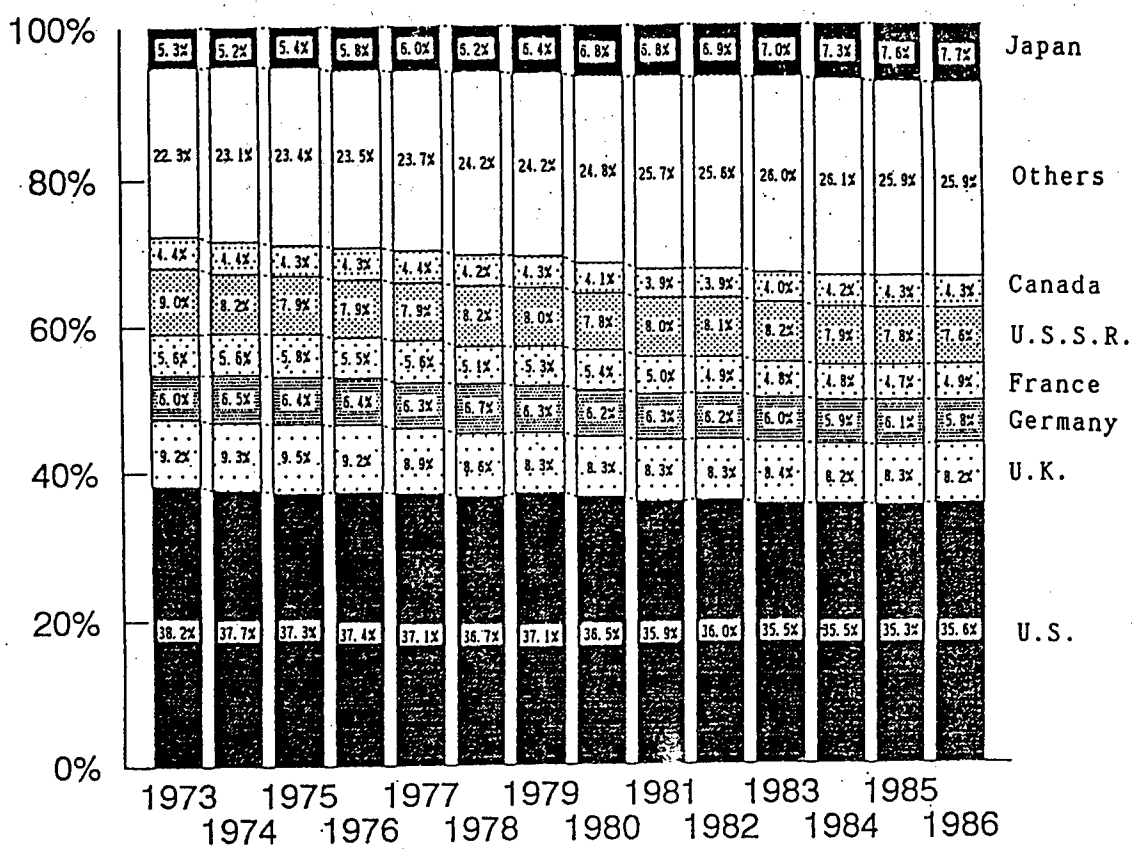


Source : Ministry of Justice "Annual Report of Statistics on Legal Migrsnts for 1989"

2) Literature

The number of papers published by Japanese researchers increased tremendously. In 1986, Japan ranked the third in this respect following the United States and United Kingdom. (Figure 4) However, in terms of number of papers per researcher, Japan ranks the last among five selected countries.

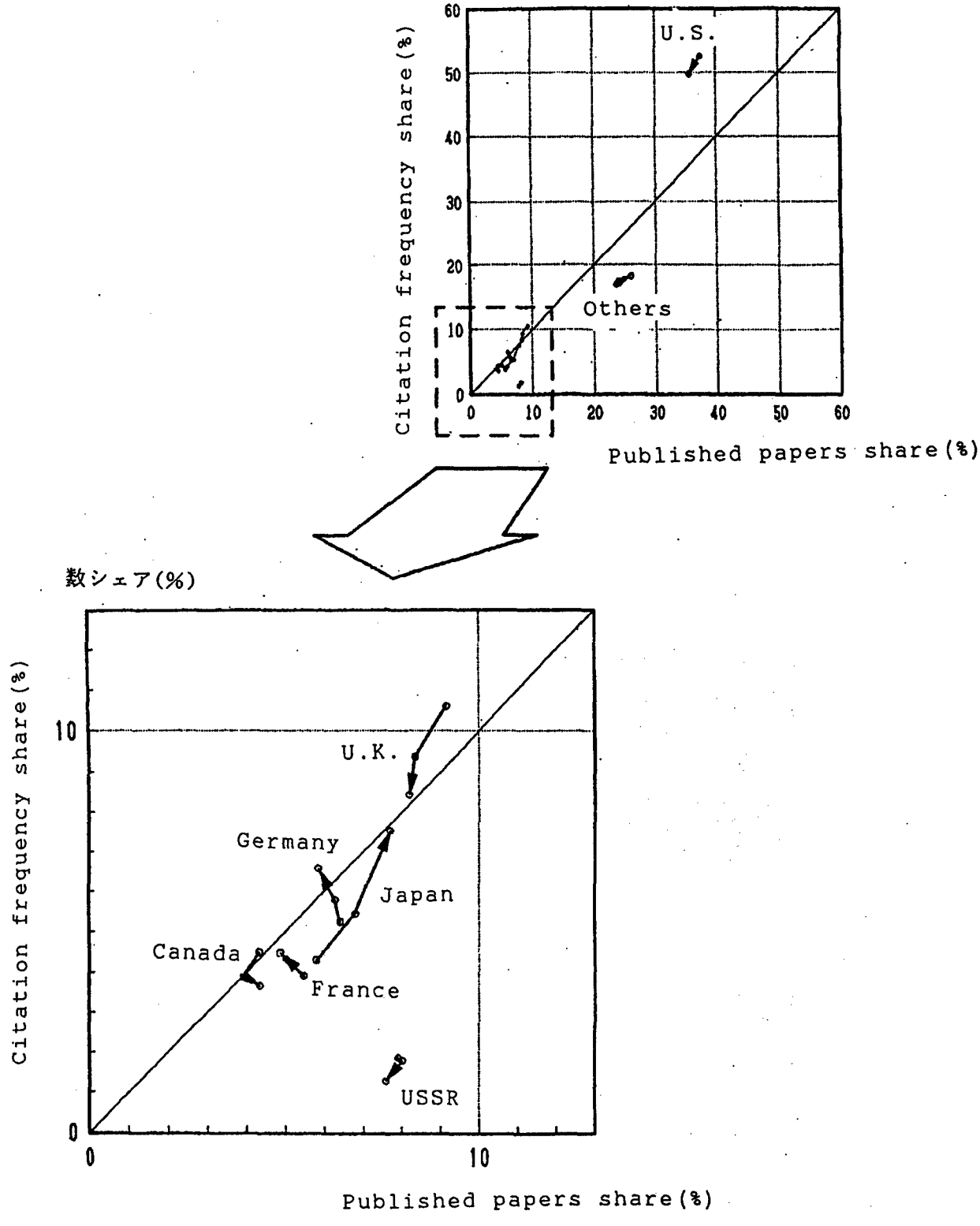
Figure 4 Changes in published papers by country



Source: NISTEP "Japanese S&T Indicator System"
Citation: Computer Horizons,Inc., Science & Engineering Literature Data Base, 1989

While Japan surpassed Germany to occupy the third position in terms of the share of quoted papers, it is inferior to the United States, Germany and the United Kingdom with regard to the relative frequency of citation (the share of number of quoted papers divided by shares of papers published). (Figure 5)

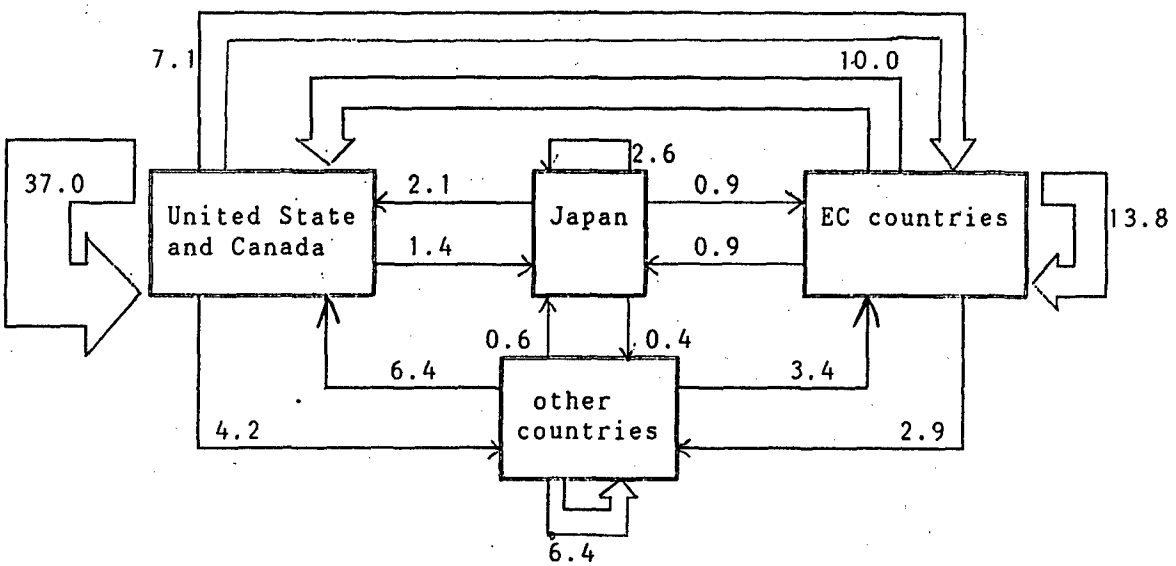
Figere 5 Changes in relative frequency of citation of papers in selected countries, 1976,81,86



Source: NISTEP "Japanese S&T Indicator System"
Citation: Computer Horizons,Inc., Science & Engineering Literature Data Base, 1989

As to the worldwide frequency of quotation, a large number of quotations exist within the United States and Canada, within the EC countries and across these regions. In contrast to this, Japanese papers cited from abroad represent no more than 3.4% of total papers cited. (Figure 6)

Figure 6 Quotation relation in the world

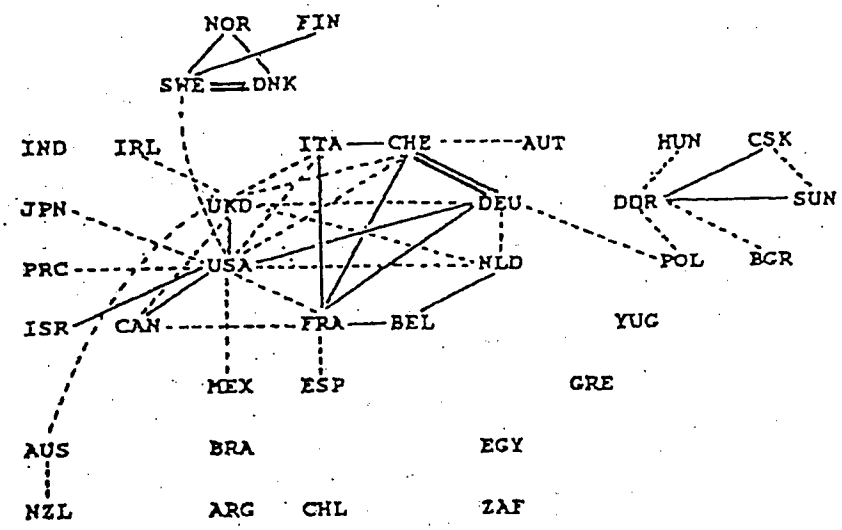


Notes) 1. Papers cited in 1984-88 are coverd.
2. Figure shows percentage of the each country's papers in the worldwide quotation.
Source : Science Citation Index (ISI Inc. USA)

Regarding the states of international co-authorships, the United States is the unchallenged leader, with strong geographic and linguistic connections generally. Japan-U.S. co-authorships exist to some extent, but few exist between Japan and other countries. (Figure 7)

In European countries, the share of co-authored papers in total number of published papers remains more or less stable, while the shares of co-authored papers decline significantly in Japan, U.S.S.R. and India. (Figure 8)

Figure 7 World map international cooperative links in the sciences, 1981-85



Notes 1) The country abbreviations used are as follows:

ARG=Argentina	AUS=Australia	AUT=Austria
BEL=Belgium	BGR=Bulgaria	BRA=Brazil
CAN=Canada	CHE=Switzerland	CHL=Chile
CSK=Czechoslovakia	DEU=Germany FR	DDR=Germany DR
DNK=Denmark	EGP=Egypt	ESP=Spain
FIN=Finland	FRA=France	GRC=Greece
HUN=Hungary	IND=India	IRL=Ireland
ISR=Islael	ITA=Italy	JPN=Japan
MEX=Mexico	NLD=Netherlands	NOR=Norway
NZL=New Zealand	POL=Poland	PRC=PR China
SUN=USSR	SWE=Sweden	UKD=UK
USA=USA	YUG=Yugoslavia	ZAF=South Africa

2) ═══ shows $2.5\% < r_{ik}$
——— shows $1.5 < r_{ik} < 2.5\%$
- - - - - shows $1.0 < r_{ik} < 1.5\%$

The relative strength r_{ik} is given by $r_{ik} = n_{ik} / (n_i \cdot n_k)^{1/2}$ where n_i and n_k is the total number of papers published by countries i and k, respectively.

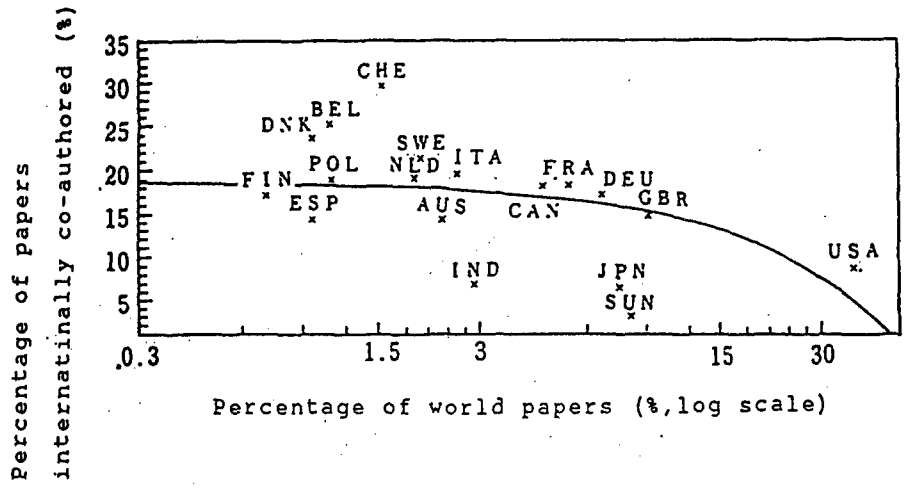
Source: Scientometrics, Vol.19, No.1-2, 1990
International Collaboration in the Sciences, 1981-85, by A. Schubert, T. Braun

Citation: ISI Inc., Data Base

3) Distribution of Information

As to the service of the Scientific and Technical Information Network(STN), the flow of information within as well as between the United States and Europe are noticeable, but access to Japanese data bases is poor. (Figure 9)

Figure 8 Size and International co-authored papers, 1981-86

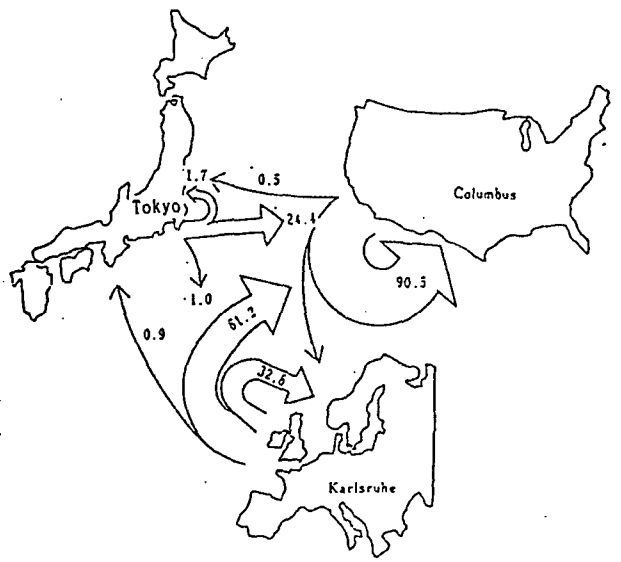


Note) The country abbreviations used are as follows:

AUS=Australia	BEL=Belgium	CAN=Canada
CHE=Switzerland	DEU=Germany FR	DNK=Denmark
ESP=Spain	FIN=Finland	FRA=France
GBR=Greate Britain	IND=India	ITA=Italy
JPN=Japan	NLD=Netherlands	POL=Poland
SUN=USSR	SWE=Sweden	USA=USA

Source: An Outline for Understading Patterns of International Scientific Collaboration By T. Luukkonen, O. Persson, G. Sivertsen

Figure 9 Usage of databases on The Scientific and Technical Information Network(STN) by connected hours



Notes) 'A→B' means 'access from B to A'.Figure shows connected hours during 1989(thousand hrs.).The related organization in each country is follwing;

Japan : Japan Information Center of Science and Technology (JICST) in tokyo

U.S.A.: Chemical Abstracts Service (CAS) in Columbus

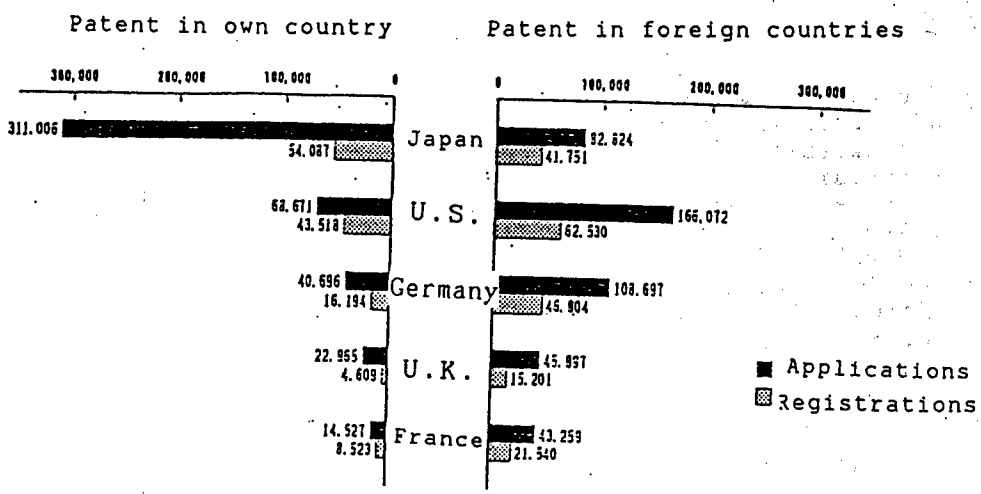
Germany : Fachinformationszentrum-Karlsruhe (FIZ-Karlsruhe) in Karlsruhe

Source : Japan Information Center of Science and Technology

4) Patents

Japan leads the world in number of patent applications filed, but the number of patents registered is far smaller in contrast. (Figure 10)

Figure 10 Patent applications/registrations in selected countries, 1987

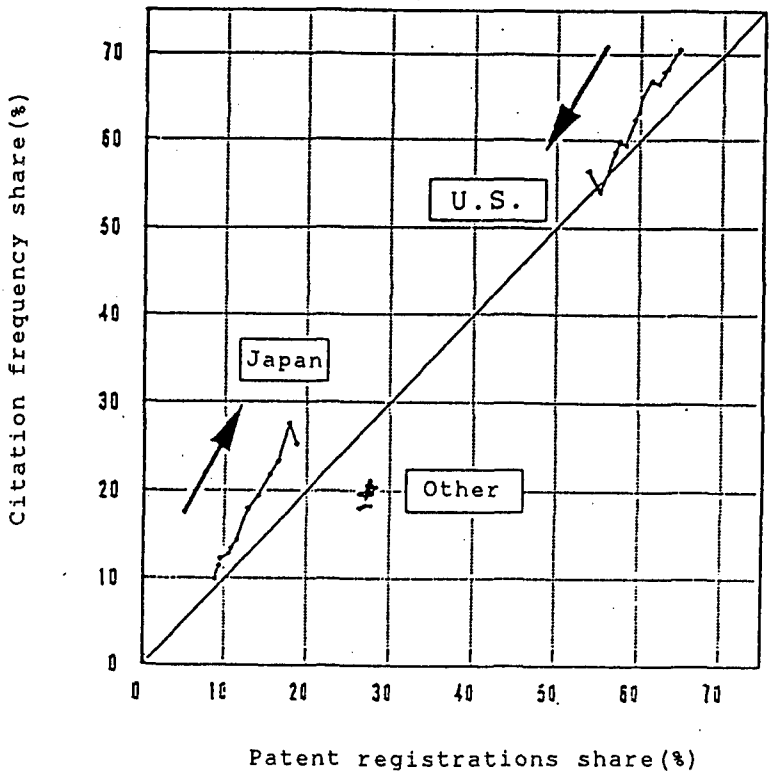


Note) As to EPC patent applications/registrations, count an appointed country as one
Source: NISTEP "Japanese S&T Indicator System"
Citation: Patent Agency "Patent Agency Yearbook, 1989"

In terms of number of foreign patent applications and foreign patent registrations, Japan comes in the third place after the United States and Germany. In the United States, however, of those companies significant for number of patents registered by them, five out of the top ten companies were Japanese in 1990.

Transition of the relative number of patents cited in U.S. patent registrations indicate an overall improvement in quality of patents obtained by Japanese applicants in the United States. (Figure 11)

Figure 11 Changes in relative frequency of citation of registered patents in U.S., 1975-86



Source: NISTEP "Japanese S&T Indicator System"
Citation: Computer Horizons, Inc.,Science & Engineering Literature Data Base, 1989

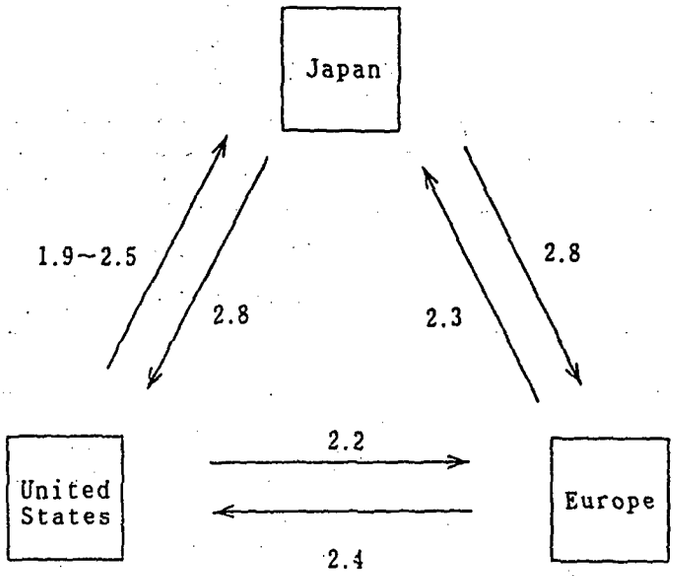
5) Trade in Technology and Trade of High-tech Products

The scale of trade in technology (patent license, knowhow transfer, technical training) among Japan, the United States and Europe doubled between 1984 and 1989. (Figure 12)

In FY 1989, overall balance of Japan's trade in technology achieved equilibrium. Trade with the United States and Europe showed deficit, while receipts from other areas exceeded payments. (Figure 13)

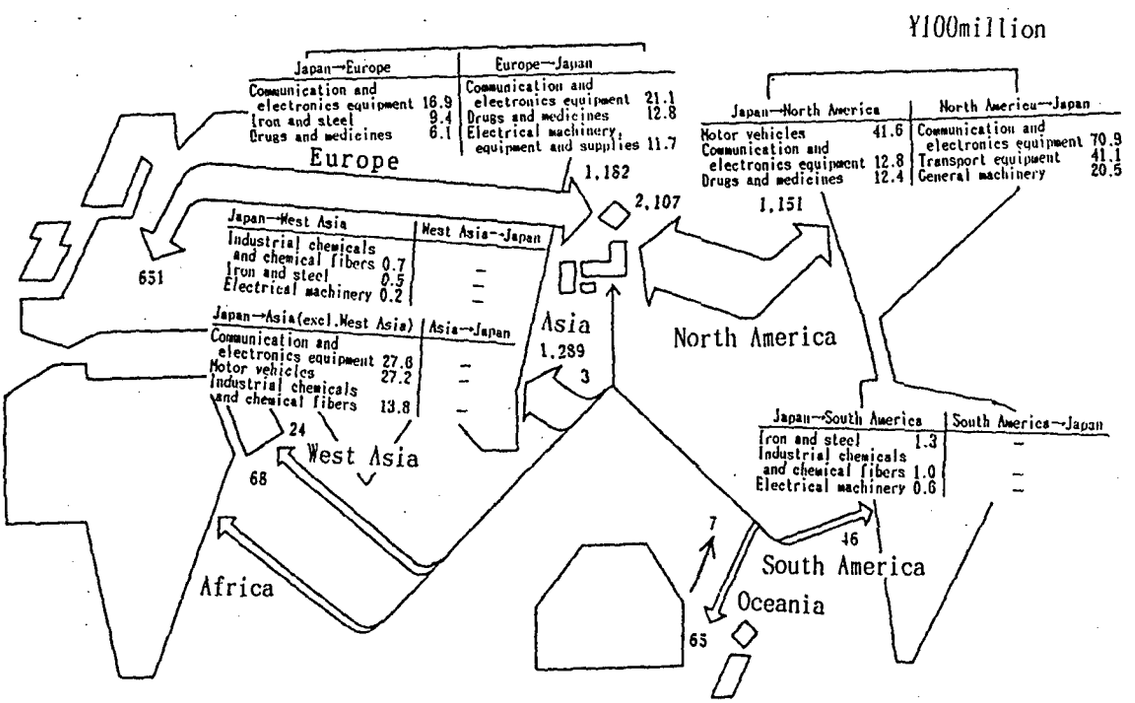
In 1986, Japan surpassed the United States and gained the first rank as the largest exporter of high-tech products. (Figure 14)

Figure 12 Expansion of trade in technology among Japan-U.S.-Europe



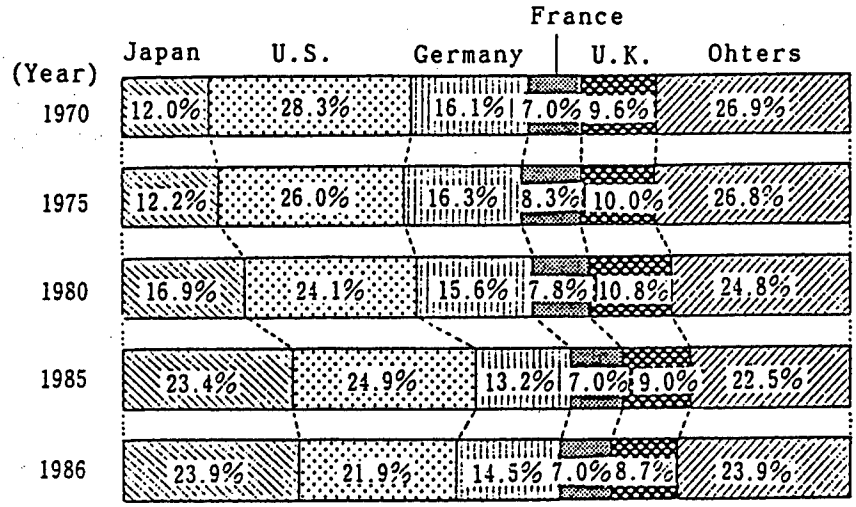
Note) Figures shown are the ratios of value of exports in technology trade in 1989 to those in 1984 (dollar based comparison).
Source: the United States Department of Commerce "Survey of Current Business"
Management and Coordination Agency, Statistics Bureau "Report on the Survey of Research and Development"

Figure 13 Trade in technology of Japan with world (1989)



Source: Management and Coordination Agency, Statistics Bureau "Report on the Survey of Research and Development"

Figure 14 Export of high-tech products by selected countries



Note) High-tech products: aerospace; office machinery, computers; electronic components; drug, medicines; instruments; electrical machinery.
Source: the U.S. National Science Board "Science & Engineering Indicators (1989)"

2. International Exchange within Governmental Policy Enforcement

(1) International Exchange of Researchers

Thanks to the start of various fellowship programs, the number of foreign researchers accepted in Japan is growing very quickly. (Table 15)

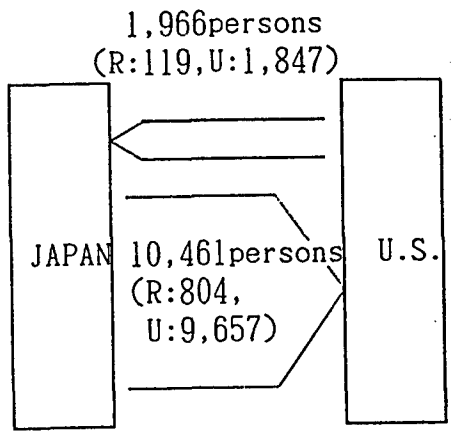
Table 15 Outline of majore fellowship programs

Name of fellowship	Field	Period	Number of awardees (FY1991 budget)
Science and Technology Agency Fellowship program	Science and Technology	6 months - 2 years	180
Japan Society for the Promotion of Science Postdoctoral Fellowship for Foreign Researchers	Natural sciences Social sciences and humanities	1 year	175
Agency of Industrial Science and Technology International Research Exchange Program	Natural sciences (industrial technology)	1 year	14

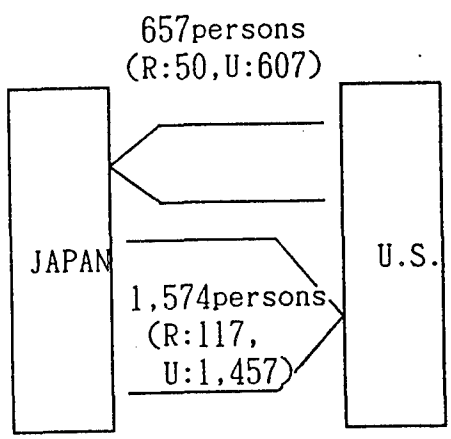
With regard to exchange of researchers between Japan and United States form the viewpoint of Japanese national research institutes and universities, the number of visitors (include short-term visit) from Japan is five times as much as that of U.S. visitors to Japan, but for those staying more than one month in the other countries, this ratio comes down to 2.4. This indicates that Japan is proposing relatively many opportunitie for foreigner to conduct research in Japan. (Figure 16)

Figure 16 Exchange of researchers between Japan and the U.S. at Japanese National Research Institutes and National Universities and colleges

(1) Exchange of researchers (including short-term visit)



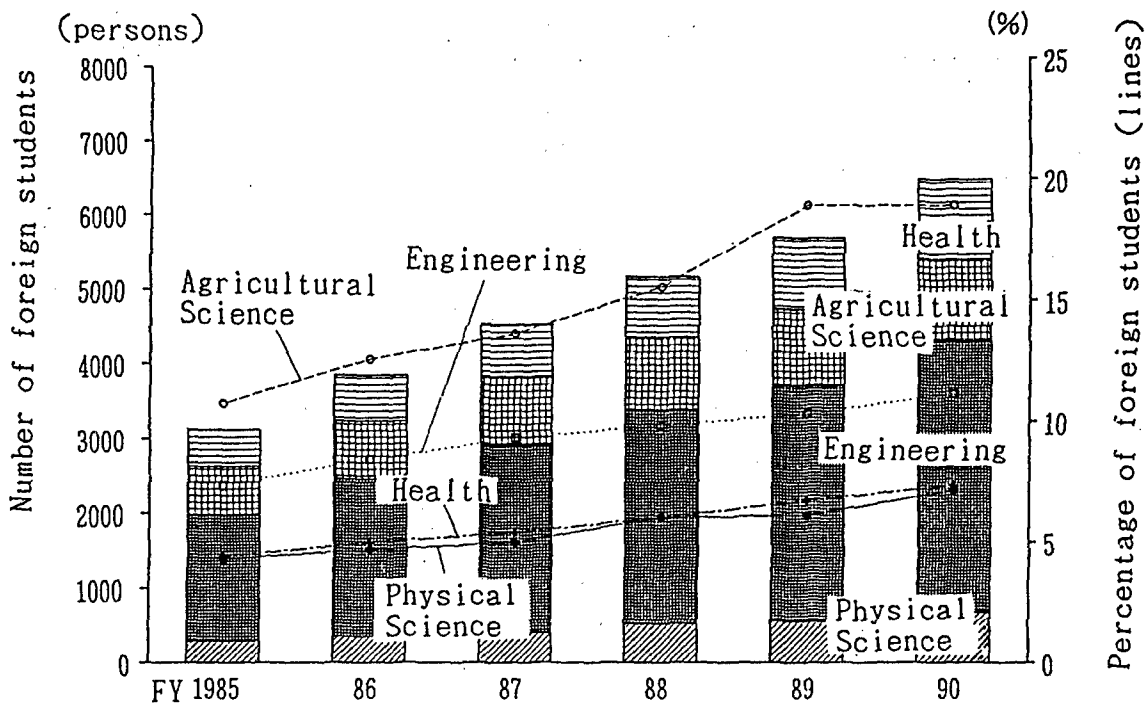
(2) Exchange of reserachers (over a month's visit)



Notes) R = National Research Institutes
U = National Universities and Colleges
Source: Science and Technology Agency
Min. of Education

Number of foreign students at Graduate Schools in Japan (Physical Science, Engineering, Agricultural Science, Health) increased 2.1 times from FY 1985 to FY 1990. The ratio of foreign students is particularly high in agricultural Science (18.9%) and engineering (11.1%) in FY 1990. (Figure 17)

Figure 17 Number of foreign students at Graduate schools (Physical Science, Engineering, Agricultural Science, Health)



Source: Min. of Education

(2) International Collaborative Research

Those collaborative research projects proposed by Japan such as HFSP (Human frontier science program), IMS (intelligent manufacturing system) Program have aroused extensive interest internationally.

The number of foreign researchers and private corporations participating to Japanese basic research programs such as ERATO (Exploratory Research for Advanced Technology), Frontier Research Program, Next Generation Fundamental Industrial Technology Research and Development Program and others is showing a steady increase.

Establishment of research facilities to overseas countries (like the installation of large-scale infrared telescope in Hawaii) is also expected to increase.

(3) Cooperation with International Organizations

Although Japan is making significant fund contributions to international organizations, the country's contribution in terms of personnel is much less than the financial contribution. (Table 18)

Table 18 Financial and personnel contribution to international organizations

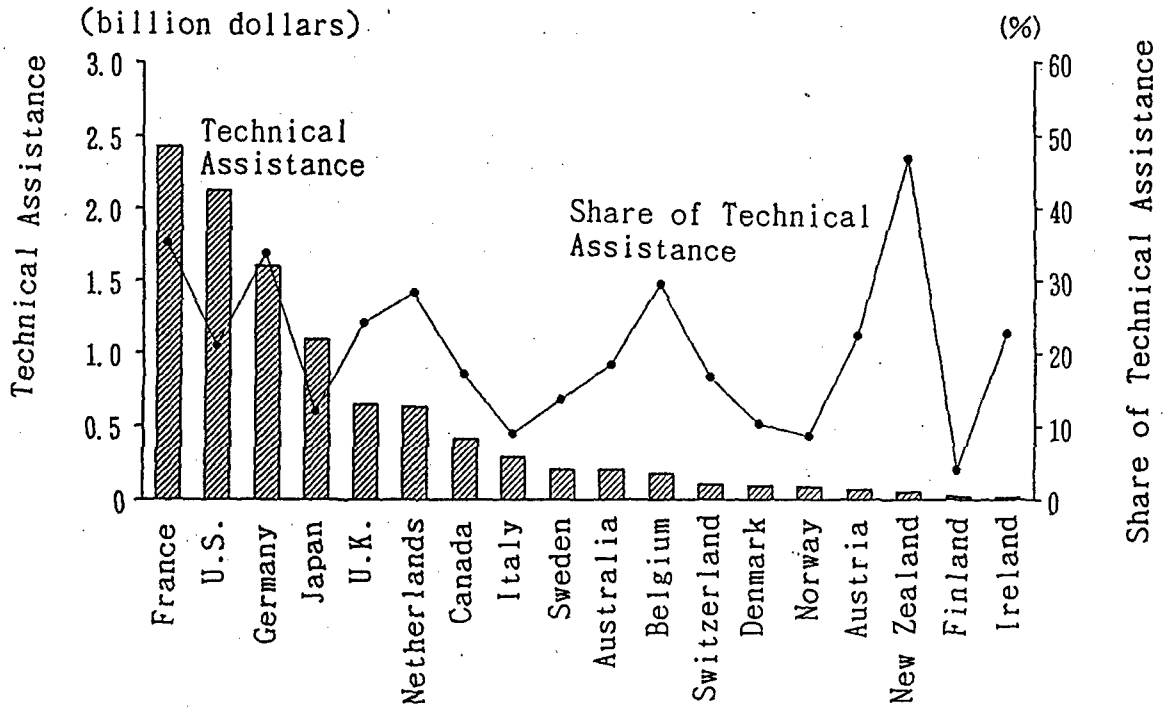
	UNESCO		WHO		IAEA		ITU	
	f. c. 1990-91	p. c. July 1990	f. c. 1990-91	p. c. Oct. 1990	f. c. 1990	p. c. Jan. 1990	f. c. 1990	p. c.
Japan	① 11.25%	⑥ 21	② 11.17%	⑥ 32	③ 11.69%	⑧ 20	7.1%	7
United States	—	② 48	① 25.00%	① 174	① 25.93%	① 104	7.1%	③ 22
United Kingdom	—	⑤ 26	4.77%	② 68	4.99%	③ 44	7.1%	④ 20
U.S.S.R.	② 9.87%	③ 37	③ 9.80%	④ 55	② 11.89%	② 59	7.1%	—
Germany	③ 7.99%	④ 30	④ 9.19%	⑤ 36	④ 8.30%	④ 40	7.1%	—
France	④ 6.18%	① 53	⑤ 6.13%	② 68	⑤ 6.42%	⑤ 37	7.1%	① 60
Italy	⑤ 3.94%	16	3.91%	26	4.10%	—	—	—
India	—	10	—	32	—	—	—	④ 20
Switzerland	1.07%	—	—	—	—	—	—	② 33

Notes) 1. f.c.: financial contribution(scale of budgetary contribution)
2. p.c.: personnel contribution(number of staffs)
3. ①,②,… denote ranking.
Source : Science and Technology Agency

(4) Cooperation to Developing Countries through ODA

Japanese share in total ODA (Official Development Assistance) amount ranked the top in the world in 1989. Japan also ranks the 4th in terms of technical assistance in 1989. (Figure 19)

Figure 19 Technical Assistance of ODA by DAC Countries (1988)



Source: Min. of Foreign Affairs "Japan's ODA"
Citation: DAC chairman's report

3. Activities of Private Corporations

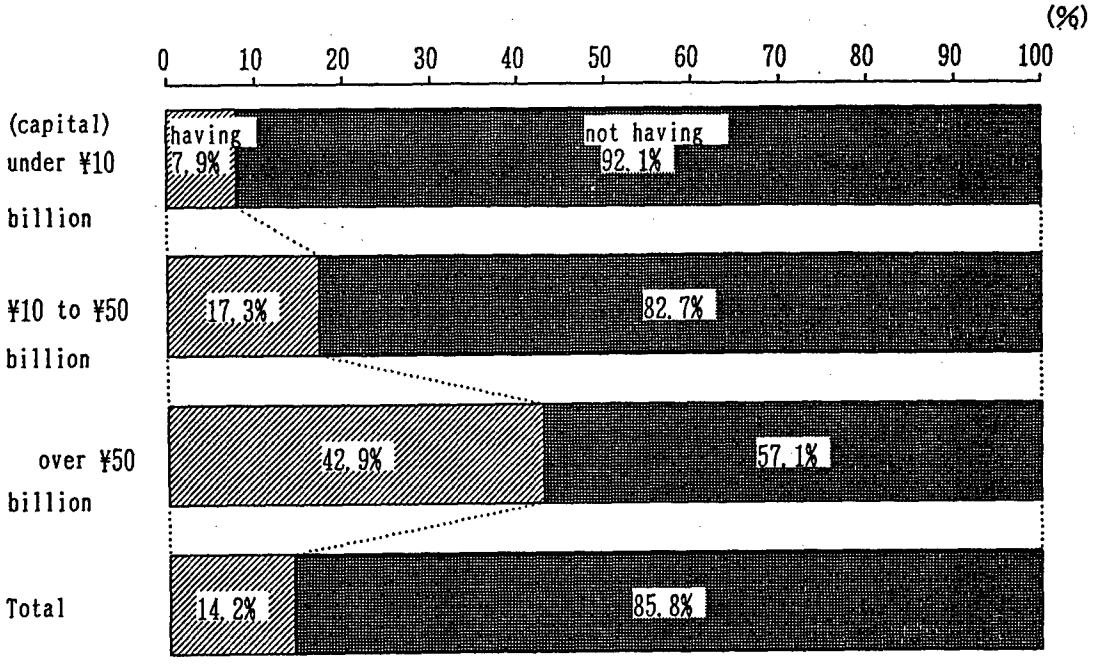
(1) Domestic and International Activities of Japanese Private Corporations in the Domain of Science and Technology

1) Establishment of Research and Development Facilities Outside of Japan

14.2% of Japanese private corporations have their research and development facilities outside of the country. (Figure 20)

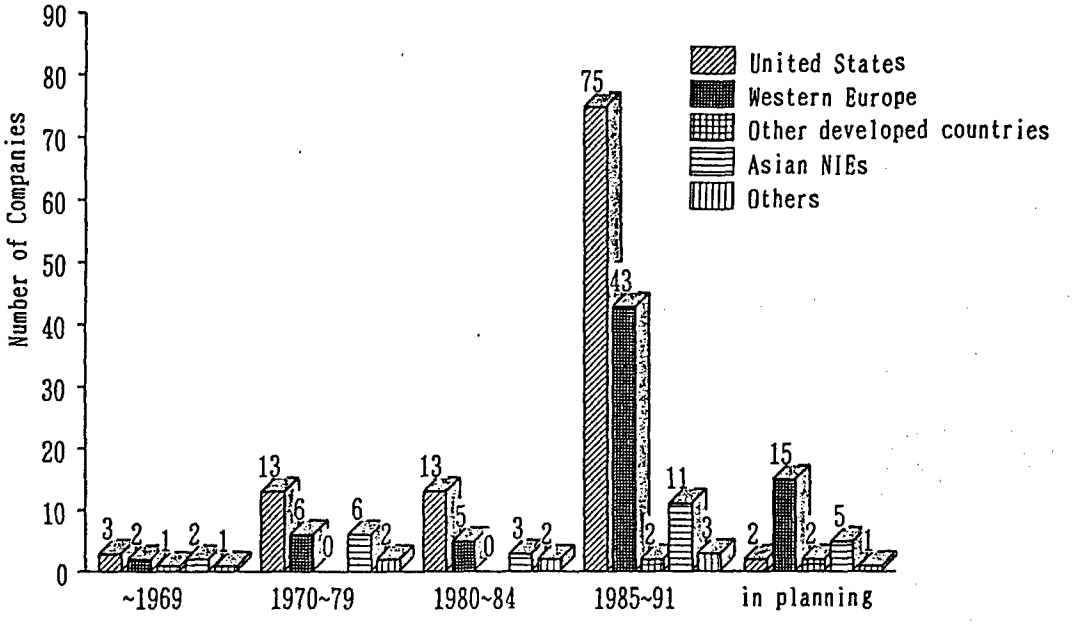
Since 1985, Japanese companies rushed to establish research and development facilities in the United States and Europe, and the trend is also extending to Western Europe in view of the accomplishment of Single Market in 1992. (Figure 21)

Figure 20 Percentage of private corporations having overseas R&D facility



Source: Science and Technology Agency "Survey on Private Enterprises' Research and Developement(1991)"

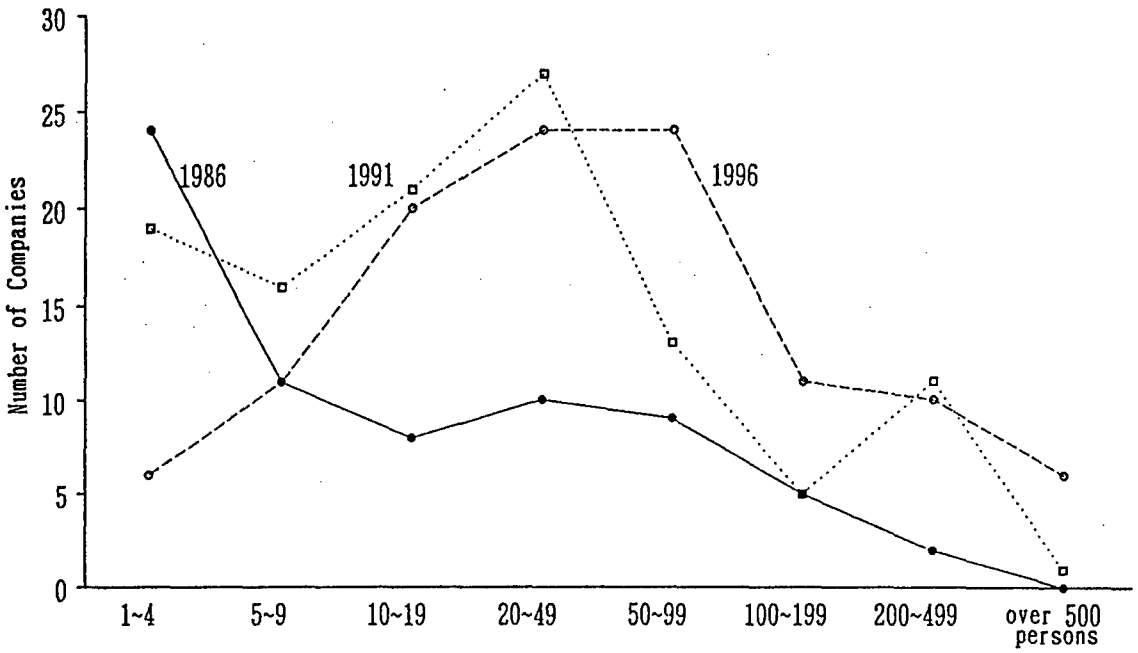
Figure 21 Period concerning the establishment of overseas R&D facilities



Source: Science and Technology Agency "Survey on Private Enterprises' Research and Developement(1991)"

Number of researchers working at these overseas facilities managed by Japanese companies is expected to increase steadily in future. The majority of these companies estimate that in five years from now, their overseas research and development facilities will employ 20 - 99 staff per each company. (Figure 22)

Figure 22 Total number of R&D personnel employed in overseas R&D facilities per company



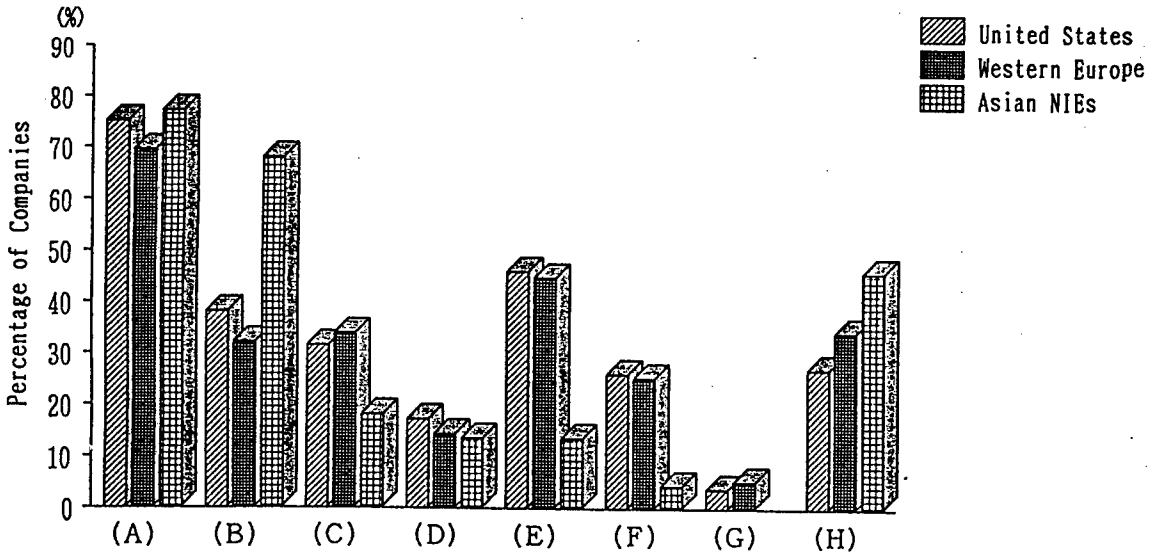
Source: Science and Technology Agency "Survey on Private Enterprises' Research and Developement(1991)"

The majority of these overseas research and development facilities have been established for the purpose of product development matched to local needs. (Figure 23)

In terms of contribution of funds and subcontracting of research projects by Japanese corporations to foreign academic institutions in FY 1990, 24% of them affirmed. These contributions and grants made to foreign institutions are at most in the order of 10 - 100 million yen. The relation between Japanese corporations and foreign academic institutions seems to be increasing. (Figure 24)

The most important task for Japanese corporations having their research and development facilities outside of Japan is to increase the efficiency of the research and development activities.

Figure 23 Motivations for establishing overseas R&D facilities

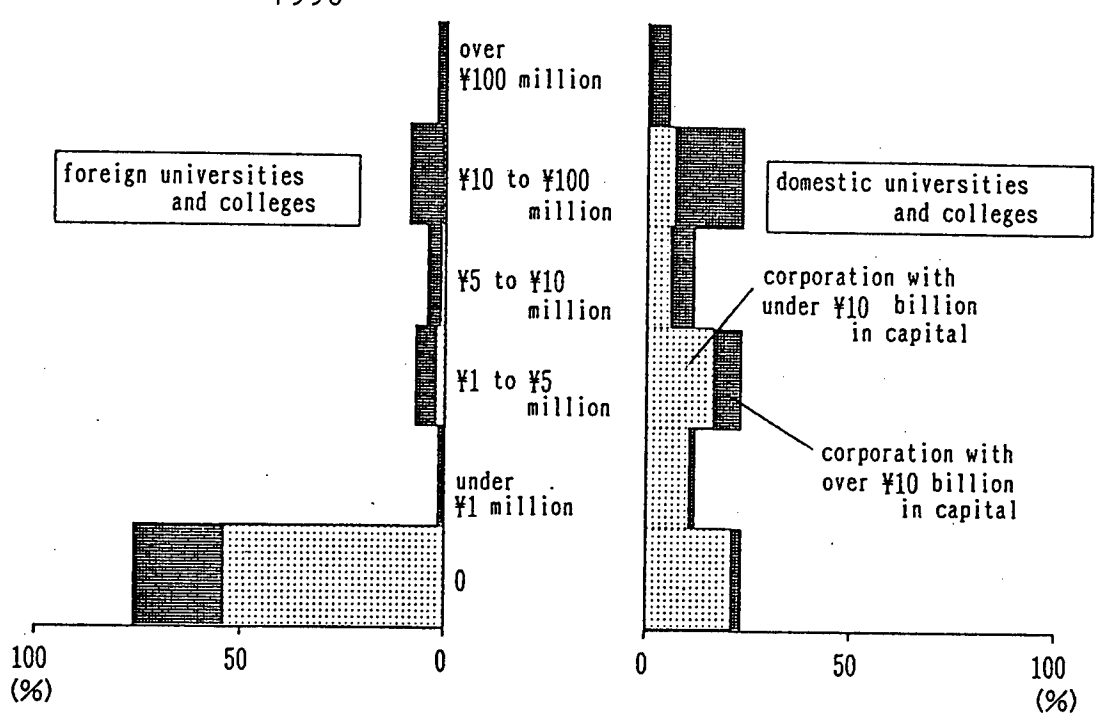


(A) To meet the local needs.
(B) To upgrade already existing productional facilities.
(C) To employ and utilize excellent R&D staff.
(D) Acquired as part of a company involved in a merger or take over.
(E) To search for the seeds of new technology.
(F) To cooperate with foreign university and/or company.
(G) To stimulate the activity of the whole company.
(H) Other reasons:

Note) Multiple response

Source: Science and Technology Agency "Survey on Private Enterprises' Research and Developement(1991)"

Figure 24 Flow of R&D fund from Japanese private corporations to universities and colleges in FY 1990

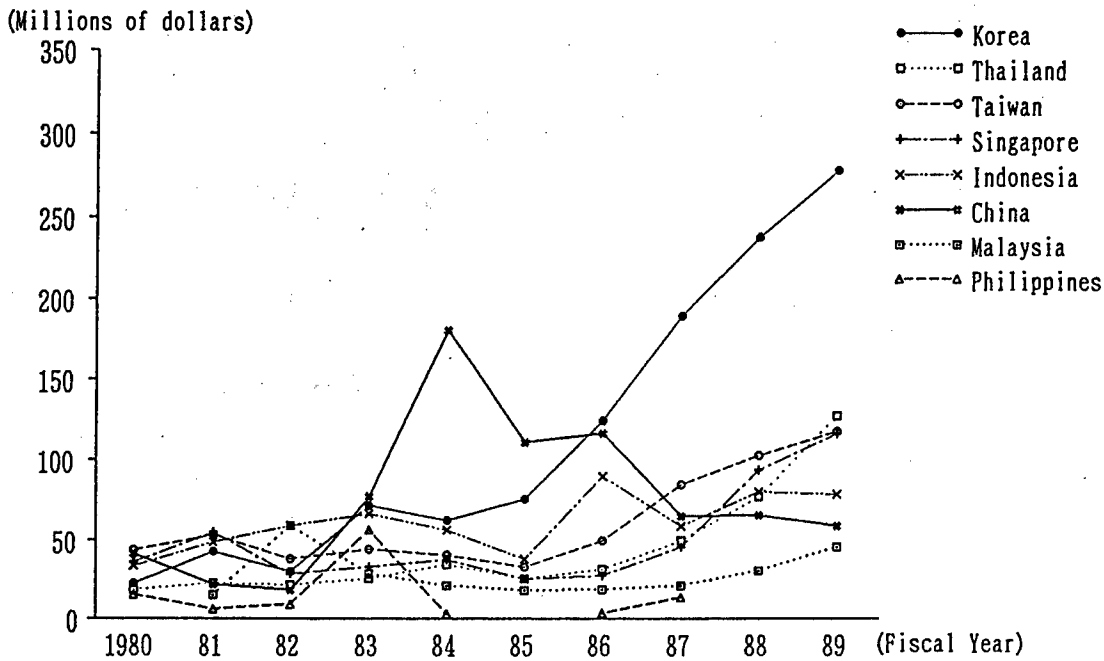


Source: Science and Technology Agency "Survey on Private Enterprises' Research and Developement(1991)"

2) Technology Transfer to Developing Countries

Japanese technology transfer to Asian countries is showing a steady increase. The growth is especially significant in Korea. (Figure 25)

Figure 25 Trends in technology exports to the neighboring countries (area)



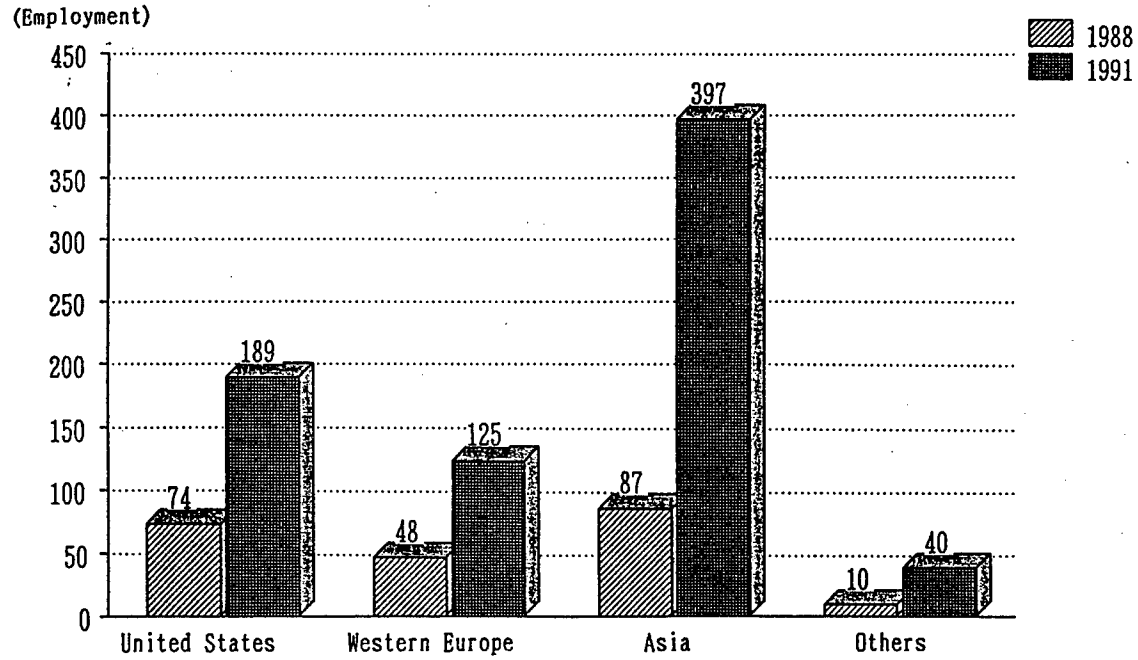
Source: Management and Coordination Agency, Statistics Bureau "Report on the Survey of Research and Developement"

3) Acceptance of Foreign Researchers

The number of foreign researchers engaged by domestic research and development institutions tripled during the past three years. Altogether there are 751 researchers. Those from Asian countries showed the most significant growth. (Figure 26)

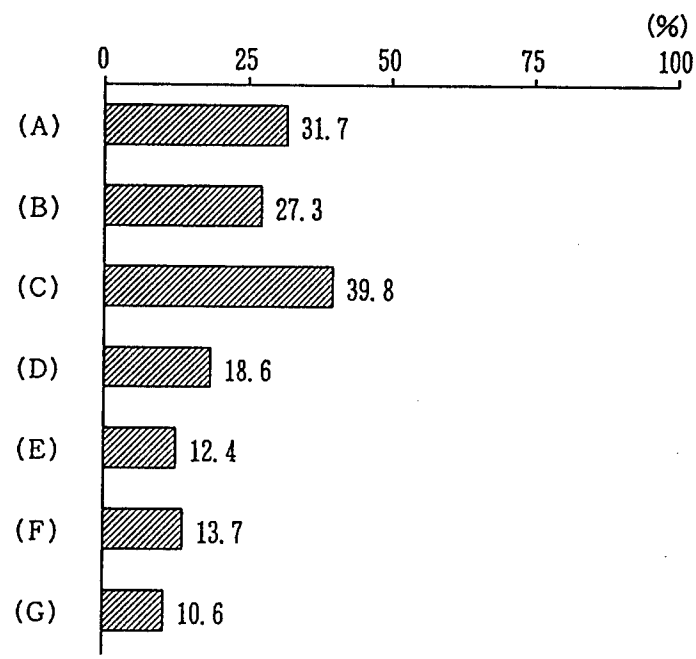
The main reason for the growth of foreign researchers is shortage of talents, as well as the desire to introduce stimuli by accepting different ideas, concepts and way of thinking. (Figure 27)

Figure 26 Foreign R&D personnel employed by private corporation in Japan



Source: Science and Technology Agency "Survey on Private Enterprises' Research and Developement(1991)"

Figure 27 Reasons to Employ Foreign Researchers

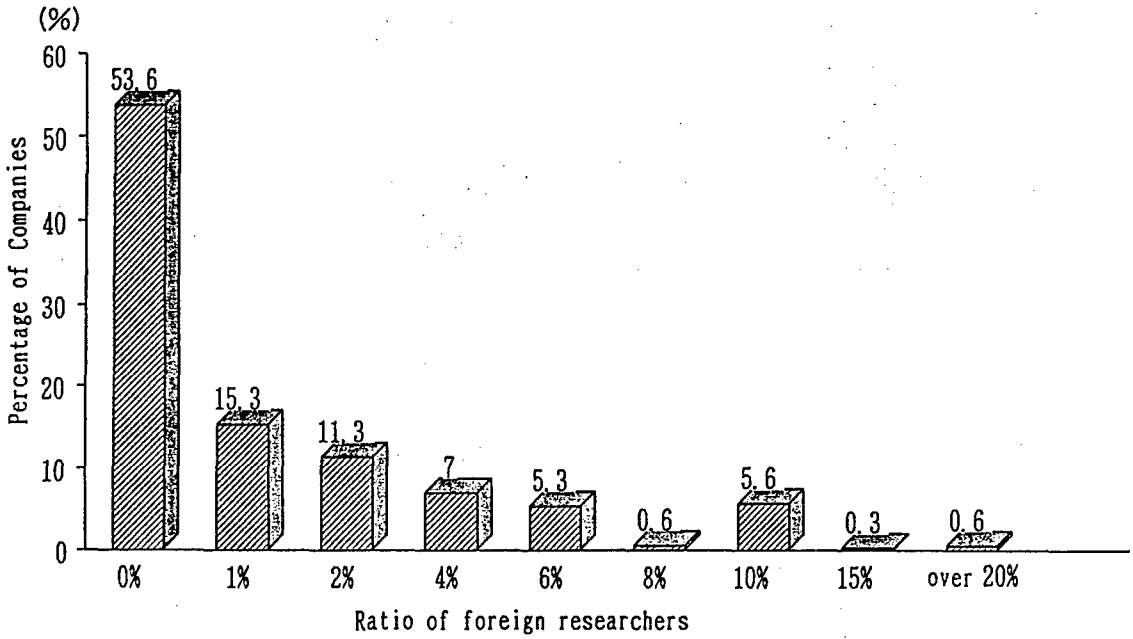


(A) Development of new technology touched off by different conception
(B) Globalization of research management
(C) Reinforcement of manpower
(D) Expectation of excellent foreign researchers
(E) To make infrastructure for future foundation of oversea facilities
(F) Policy of the company
(G) Others

Note) Multiple response
Source: Science and Technology Agency "Survey on Private Enterprises' Research and Development (1991)"

27% of Japanese private corporations responded that the share of foreign researchers they intend to employ in the future would be 1% or 2%, although 6% of the respondents stated that the share would be likely to be overe 10%. (Figure 28)

Figure 28 Expectations for the ratio of foreign researchers employed by private corporation in Japan in the future



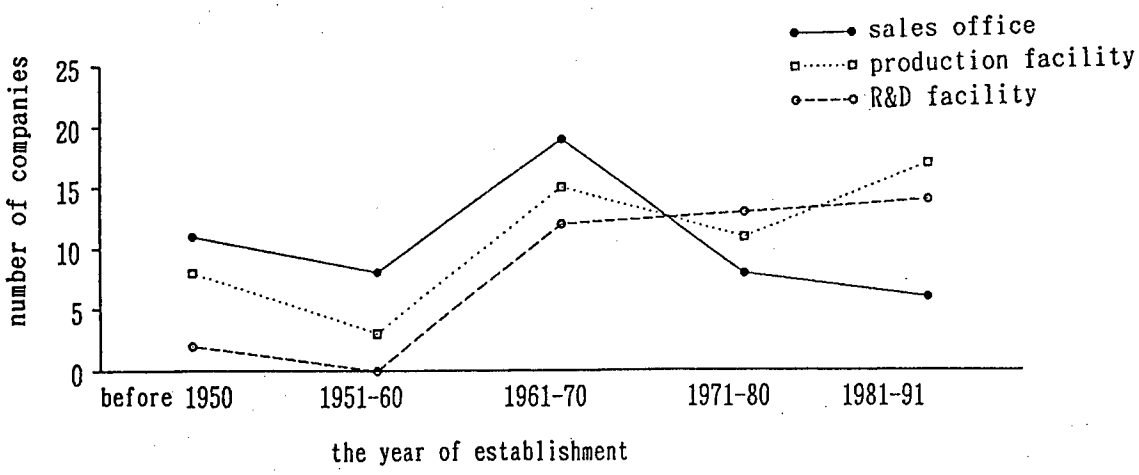
Source: Science and Technology Agency "Survey on Private Enterprises' Research and Developement(1991)"

(2) Research and Development Activities of Foreign-Affiliated Companies in Japan

Foreign-affiliated companies operating in Japan tend to start from establishment of sales/distribution functions, followed by that of manufacturing locations and finally by research and development facilities. (Figure 29)

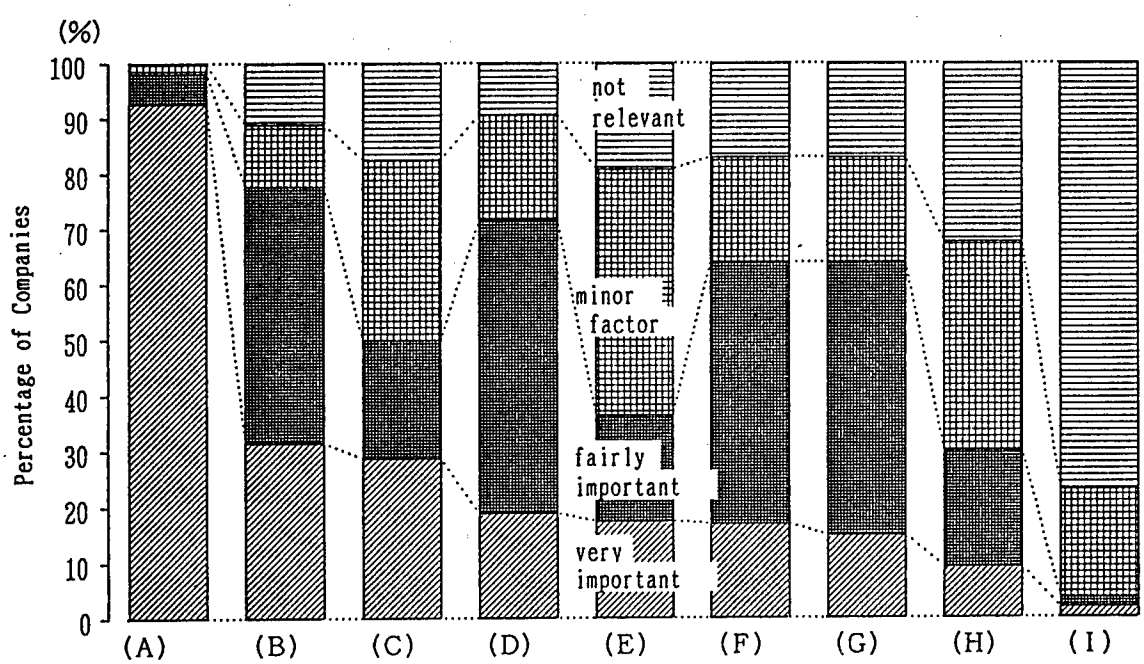
These foreign-affiliated companies typically stated that their Japanese research and development facilities are needed for the purpose of developing products suited for Japanese market. In the second place, they cited the advanced level of research and development in Japan as the motive to set up such facilities locally. (Figure 30)

Figure 29 Period of establishment of foreign-affiliated companies in Japan



Source : National Institute of Science and Technology Policy

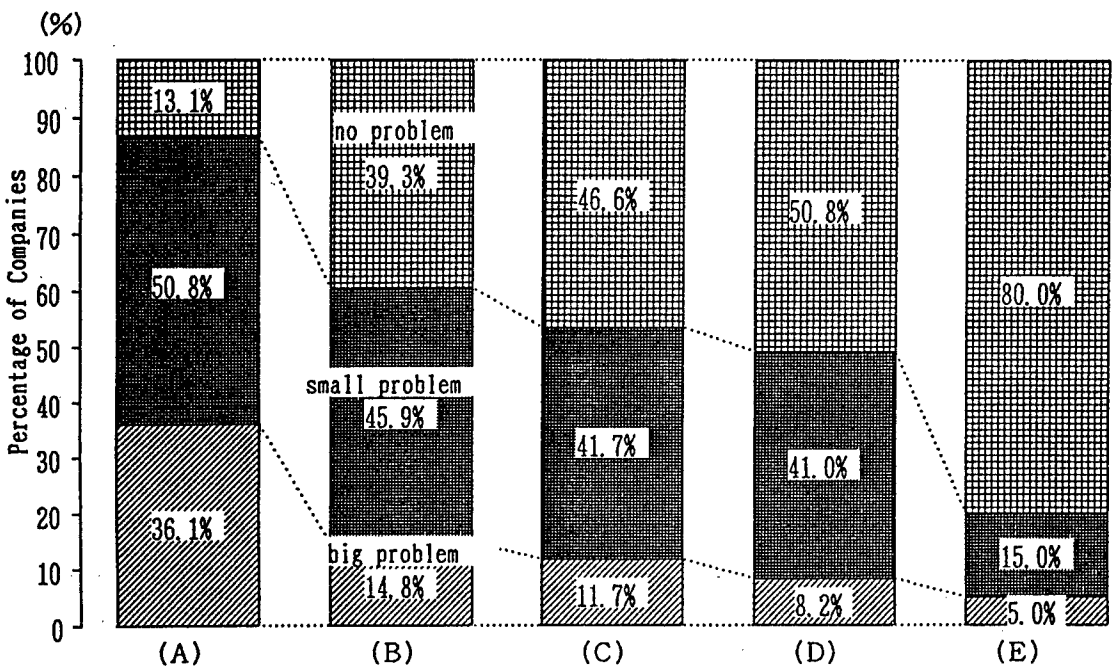
Figure 30 Reasons foreign-affiliated companies perform R&D in Japan



(A) To plan and localize new products meet host country needs.
(B) Japan seen as leader in R&D in my field.
(C) To monitor technological developements and activities.
(D) Japan seen as leader in production technology in my field.
(E) To conduct strategic analysis of competitors.
(F) Existence of outstanding engineering personnel
(G) Existence of outstanding research personnel
(H) To upgrade already existing production facilities.
(I) Japanese government incentives
Source: National Institute of Science and Technology Policy

Few of these companies said they had experienced any problem from bureaucratic control of the Japanese governments. The majority stated the main difficulty was recruitment of qualified personnel. (Figure 31)

Figure 31 Problems foreign-affiliated companies face in carrying out R&D activities in Japan



(A) Attracting qualified research personal
(B) High cost of establishing R&D operations
(C) Patent office procedures
(D) Harmonizing research activities with parent company
(E) Goverment regulations
Source: National Institute of Science and Technology Policy

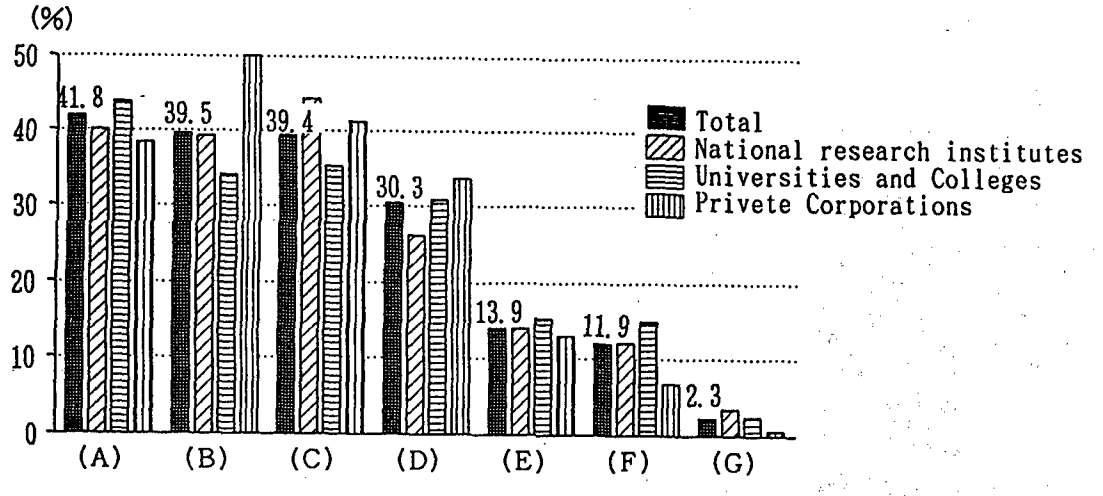
Section 3. New Problems

1. Global Environmental Problems

Much remains to be done in order to elucidate scientifically those problems relating to global environment. We must intensify our efforts to make the best use of our scientific and technological resources to that end.

Research and development are of course effective to resolve the global environmental problems, but at the same time, we need to improve our own lifestyles and mechanism of economic activities. (Figure 32) Science and technology can play a vital role in this context as well.

Figure 32 Most effective measures to solve global environmental problems



(A) Improvement of living style
(B) Promotion of R&D
(C) Improvement of economic mechanism
(D) Strengthening of regulation
(E) Assistance to developing countries
(F) Combination of various measures
(G) Others

Note) Multiple responses
Source: Science and Technology Agency
"Survey of High-tech Researchers and Engineers (1991)"

2. Approach to "Megascience"

As science and technology advance, they require ever larger resources in terms of research facilities, expenditures and qualified researchers. The tremendous magnitude of these investments in "megascience" now makes international cooperation essential, of which Space Station and nuclear fusion programs are typical examples. At the same time, individual countries are becoming increasingly aware of the need to find ways and means to minimize adverse impact of the megascience on the ordinary research, which is called "small science".

Section 4. Conclusion

In 1986, Japan occupied the top position as exporter of high-tech products. The country's spending in research totalled 10 trillion yen in FY 1988. Japan lead the world in FY 1989 in terms of the share of research expenditure as a percentage of GNP, while balance of trade in technology achieved equilibrium in the same year. These records indicate that the country's scientific and technological activities is making a steady advance. (Table 33)

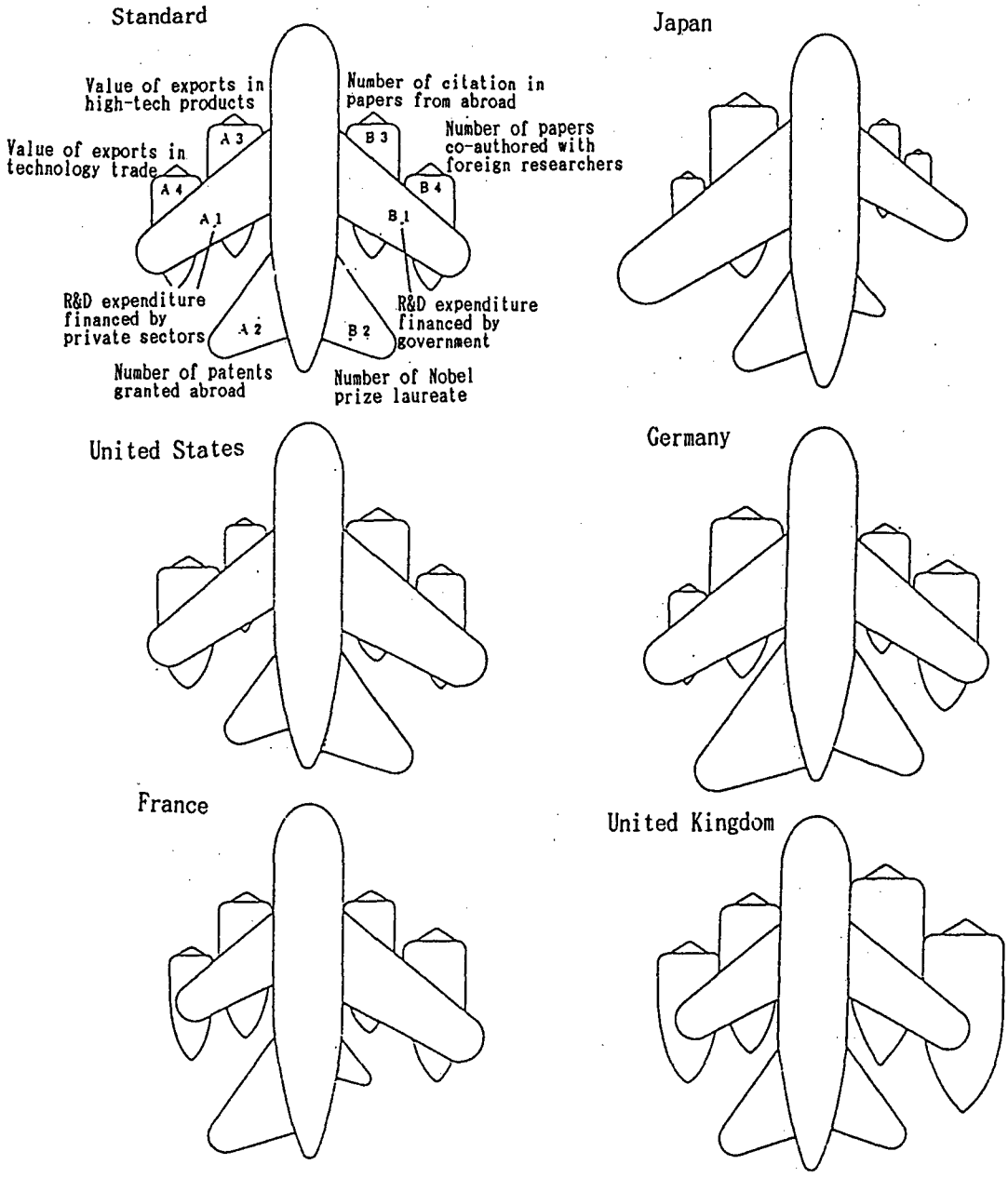
Table 33 Recent Trends relating to S&T

1985	Japan' participation in Space Station Project Launching of EURECA Plan
1986	Japan becoming No.3 after U.S., U.K. in producing papers Japan becoming top in High-tech product export
1987	Launching of HFSP Rapid increase of Japanese companies' R&D facilities abroad 5 Japanese companies among best 6 companies in patent registrations in U.S. Launching of doubling the NSF budget in the U.S. Starting of programs in Japan to invite foreign researchers (STA fellowship etc.)
1988	Japan's R&D expenditures breaking ¥ 10 trillions Japan-U.S. Science & Technology Cooperation Agreement concluded
1989	Japan's R&D expenditures as a percentage of GNP becoming top in the world Japan's technology trade balance becoming even
1990	U.S. proposing SSC Project Virtual agreement on engineering design activities of ITER

Source: STA

In comparison with other major advanced countries, scientific and technological activities in Japan are characterized by their strength in technological aspects such as total research expenditure

Figure 34 Comparison of science and technology activities by selected countries



Notes) 1. Each figure indicates relevant countries' scales in science and technology activities compared with its national powers (GNP).
("Standard" figure indicates the normal form (in area) when one country has equal ratio of scale in relevant science and technology activities to its national power.)

2. A1: R&D expenditure financed by private sectors,
A2: Number of patents granted abroad,
A3: Value of exports in high-tech products,
A4: Value of exports in technology trade,
B1: R&D expenditure financed by government,
B2: Number of Nobel prize laureate,
B3: Number of citation in papers from abroad,
B4: Number of papers co-authored with foreign researchers.

by private sector, export of high-tech products and so on (refer to the left side of each figure on the Figure 34) and weakness in basic research which can be seen from low level of governmental spending in research, number of Noble Prize laureates, frequency of citation of papers published from abroad and number of international co-authorships (right side of each figure on the Figure 34). This lack of equilibrium shows that Japan's activity in basic research doesn't accord with its station in the world.

Chapter 2. Promotion of Globalization of Scientific and Technological Activities

In Chapter 1, it became apparent that the globalization in the domain of science and technology is nearly advancing, but Japan's activity in basic research is far behind other advanced countries. Recognizing this present situation, we shall first try in this chapter to identify "the point of view for Japan to promote globalization of scientific and technological activities". Following this, and based on the idea, we shall analyze two critical tasks for Japan, namely "to seek the internel globalization", and "to participate in building up the common sense of values and rules to be respected by nations in supporting globalization of scientific and technological activities".

Section 1. The Point of View to Promote Globalization

The following reasons make it essential for all nations in the world to cooperate closely for the sake of globalization of scientific and technological activities in future:

(i) The results of basic research need to be shared by all as common assets;

(ii) In the domain of technology, there is a trend to provide excessive protection to intellectual property, such as the right of inventors. However, the side of international public goods inherent in technology should be fully utilized for well-being of mankind.

(iii) All nations must unite their efforts to cope with tasks aiming at harmonious coexistence of mankind on the earth, and with large-scale scientific and technological activities, which reqiure broad cooperation among nations.

Even if other countries are inclined to give excessive protection to their own technological properties, Japan is committed to take initiatives on its own in order to promote globalization of scientific and technological activities.

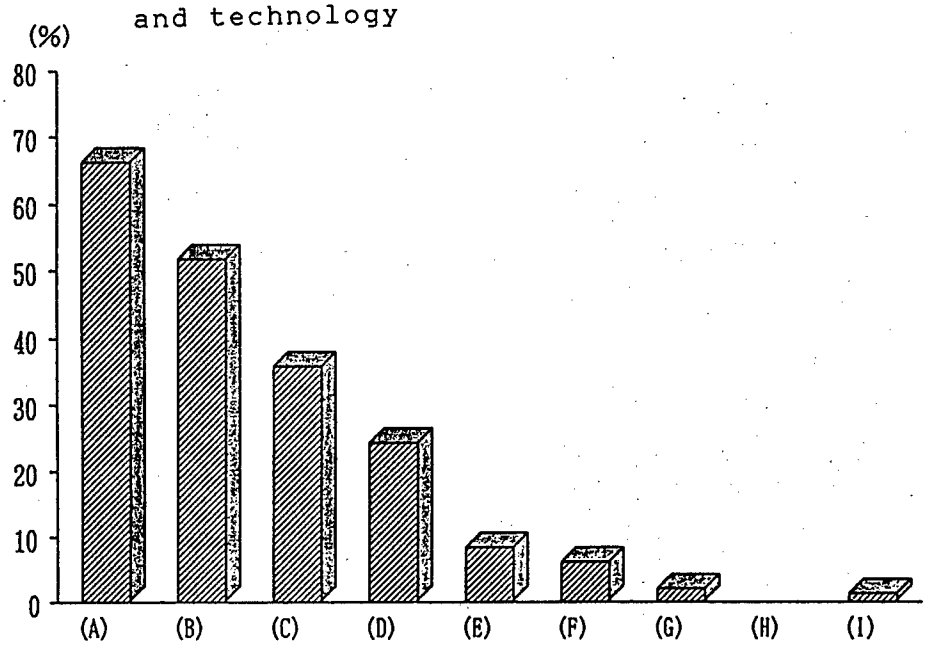
Section 2. Characteristics of International Cooperation in the United States and European Countries (omitted)

Section 3. Towards The "Internal Globalization"

1. Formation of an Intellectual Stock as International Public Goods

Japan's major international responsibilities in the domain of science and technology are an accumulation of intellectual property through its domestic basic research efforts, a promotion of international collaborative research projects and so on. (Figure 35)

Figure 35 International role of Japan in the field of science and technology

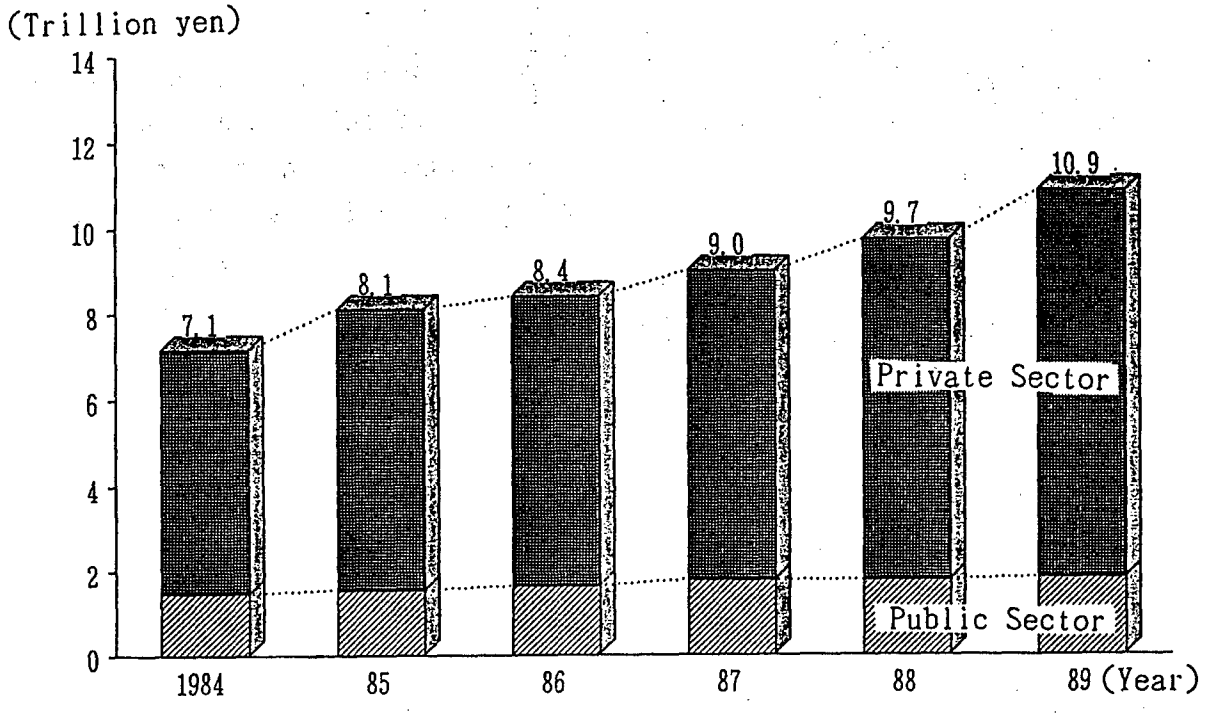


(A) Accumulation of intellectual property with further expansion of basic research in Japan
(B) Promotion of international research cooperation
(C) Increase of researcher and engineer exchanges between Japan and developing countries
(D) Increase of researcher exchanges between Japan and developed countries
(E) Establishment of research institutes(facilities) in foreign countries
(F) Transfer of private corporation's technologies to foreign countries
(G) Financing overseas megascience
(H) Present activities are already sufficient.
(I) Others

Note) Muliple response
Source : Science and Technology Agency "Survey of High-tech Researchers and Engineers (1991)"

The portion of governmental research funding is becoming smallere, because of the quick increase of private sector funding. (Figure 36)

Figure 36 R&D Expenditures by Source of Funds

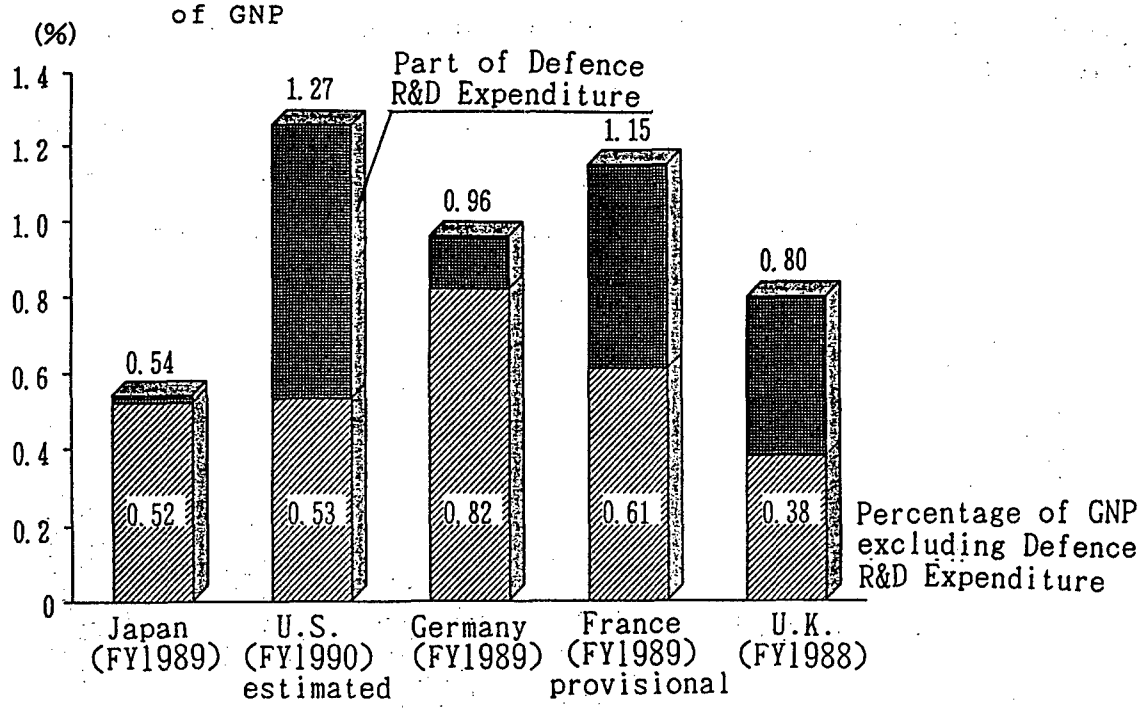


Source: Management and Coordination Agency, Statistic Bureau
"Report on the Survey of Research and Development"

Japan's R&D expenditure financed by government as a percentage of GNP is approximately one half of those in the United States, France and Germany. (Figure 37)

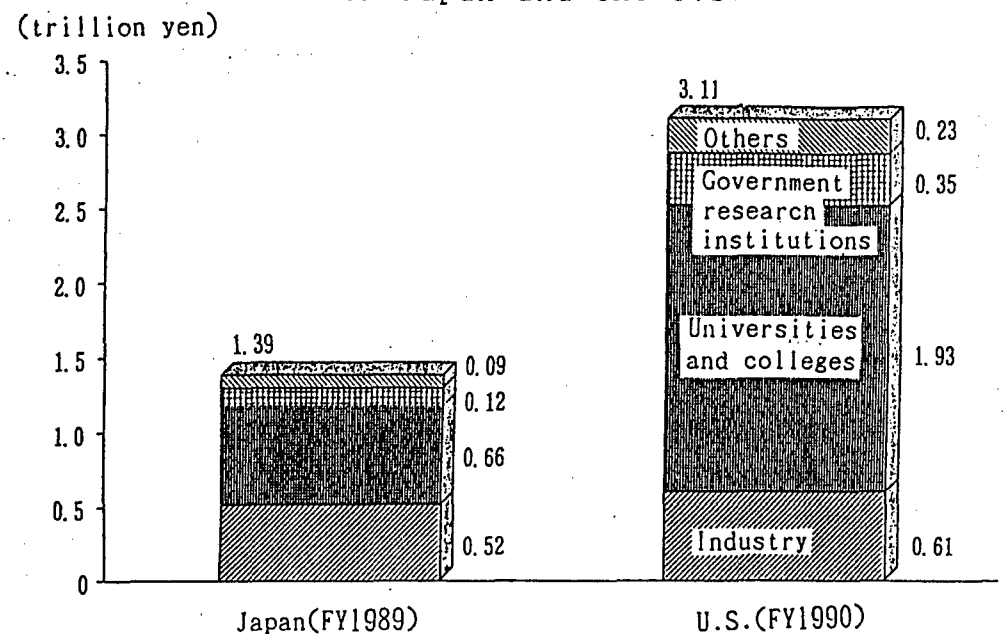
A comparison of R&D Expenditure in basic research in Japan and the Unite States shows that financial contribution of the government to basic research is much smaller in Japan. (Figure 38)

Figure 37 R&D Expenditure Financed by Government as a Percentage of GNP



Source: Statistics of relevant nations

Figure 38 Comparison of basic R&D expenditures between Japan and the U.S.



Note) The data for Japan is natural sciences only.
Source: Japan;Management and Coordination Agency, Statistic Bureau "Report on the Survey of Research and Development"
U.S. ;NSF,"National patterns of R&D resources:1990"

2. Need for Human Resources

According to the expected quick decrease in population of younger generation over the year 2000, a chronic shortage of researchers is expected to occur in future. Because of this, more efforts are needed to secure researchers.

3. Improvement of Research Infrastructure and Environment

Surveys show that Japan is generally inferior to other western countries in terms of research laboratory space, availability of experimental facilities and their maintenance. However, the survey results indicate at the same time that Japan is equal to other advanced countries with regard to availability of experimental facilities at the national research institutes and private corporations as well as in terms of maintenance of such facilities at private corporations. (Figure 39)

The surveys also suggest that researchers enjoy higher social status in those countries, while evaluation standards for research itself tend to be more strict there.

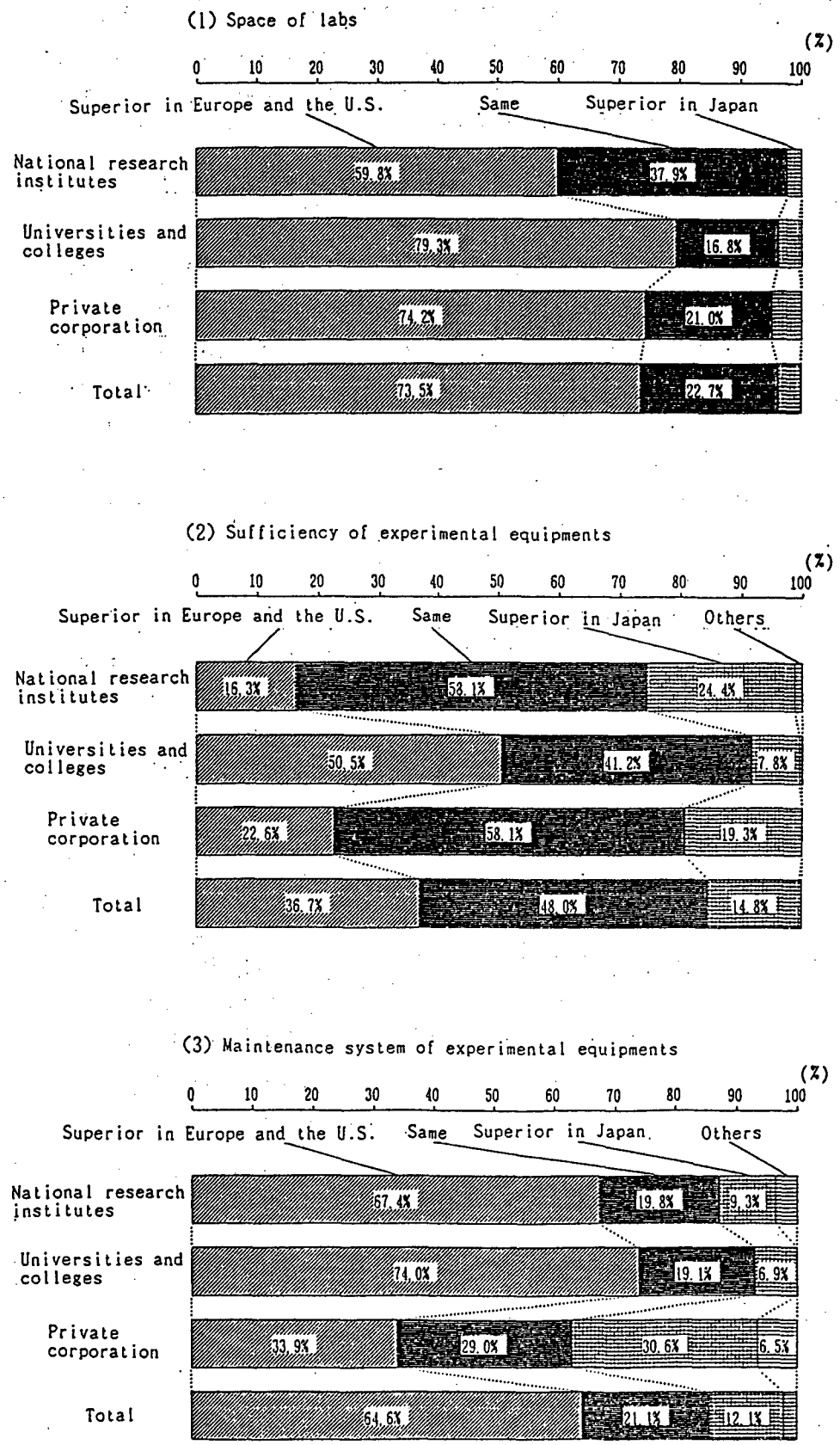
4. Promotion of Acceptance of Foreign Researchers

Majority of Japanese and the United States researchers responded that language barrier is the greatest problem for them to conduct researches in the other countries, the United States researchers consider housing and job availability for their spouses more serious. (Figure 40)

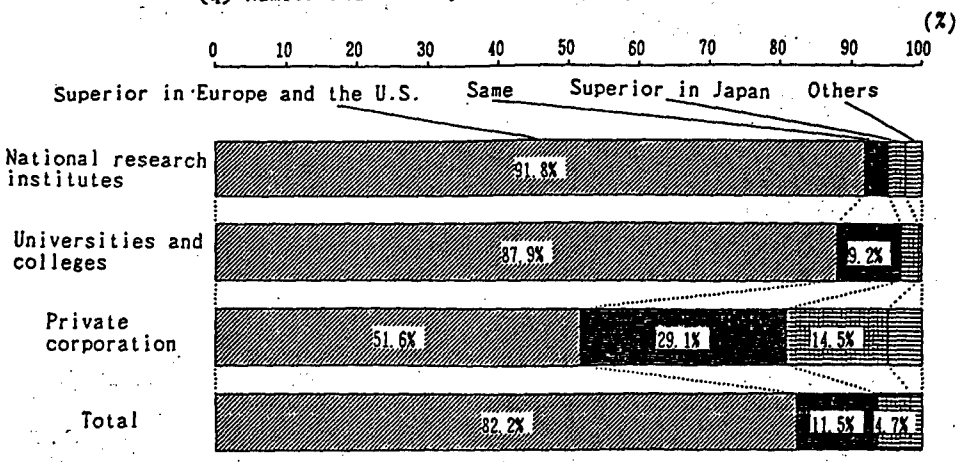
5. Promotion of Distribution of scientific and technological Information

The greatest problem for the international dissemination of Japanese scientific and technological information comes from the fact that Japanese is not an international language. In order to translate vast amounts of information into English, it is now an urgent task to improve Japanese-English machine translation systems. In addition, to facilitate use of Japanese scientific and technological information by overseas researchers, clearance system

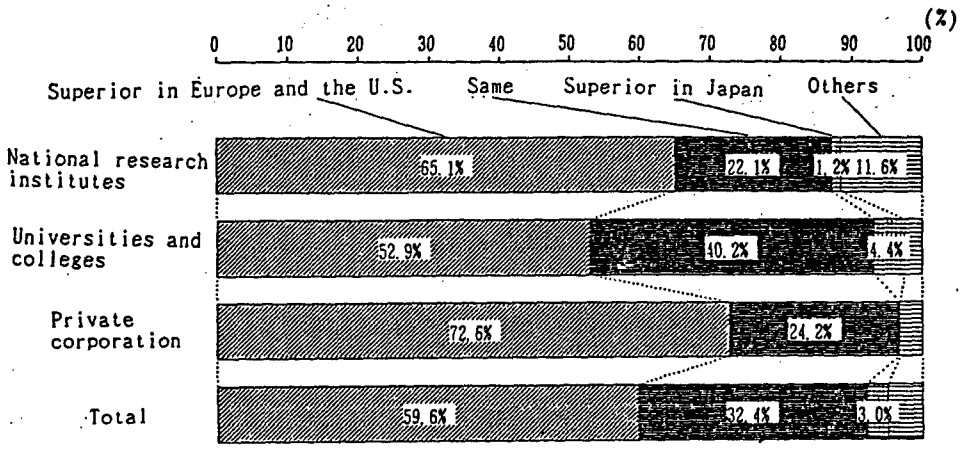
Figure 39 International comparison of research environments



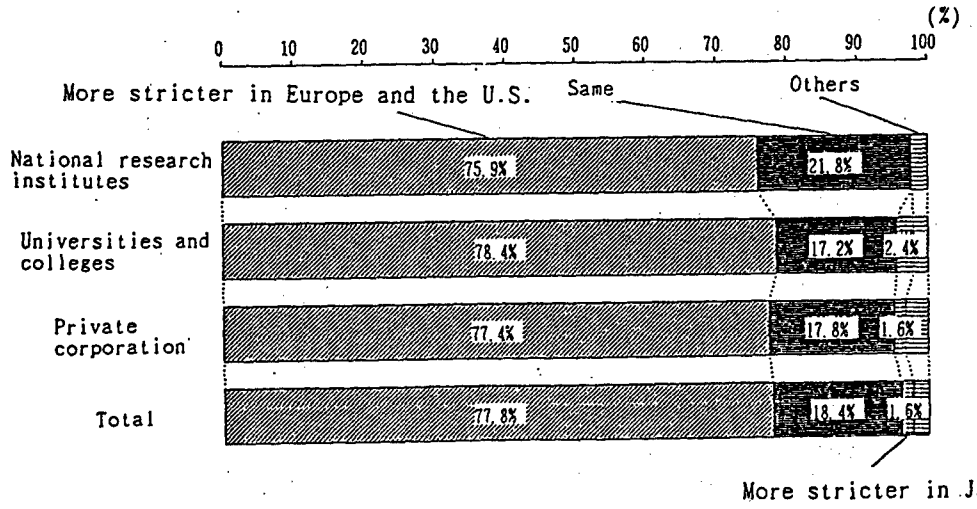
(4) Number and ability of assistant persons



(5) Social status of researchers

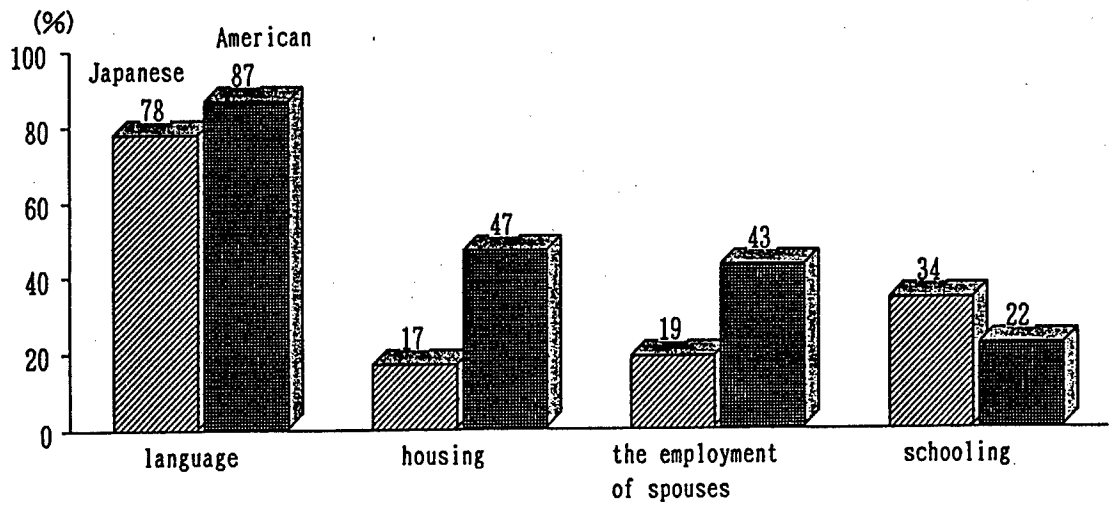


(6) Strictness of research evaluation



Source: Science and Technology Agency "Survey of High-tech Researchers and Engineers (1991)"

Figure 40 The most significant barriers on doing research in the other country



Note) Multiple response
Source : Data on 'the Task Force on Access' established under "The Japan-U.S. Science and Technolgy Agreement"

of reprographic rights must be developed.

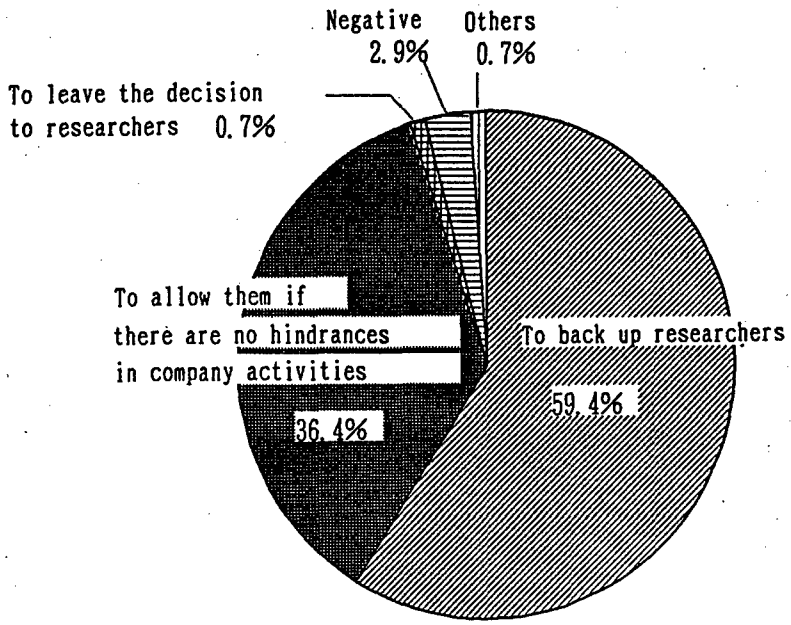
As a above mentioned reprographic rights organization, a plan is now being implemented to establish "Japan Reprographic Right Center".

6. Advance of Private Corporations in the Domain of Basic Research

Recently, more and more Japanese corporations are becoming active in the field of basic research. The majority of these companies responded that they were supporting publication of results of their basic research. (Figure 41)

Japanese companies are facing need to establish management philosophy and approach which can be applied all over the world.

Figure 41 Attitude of Private Corporations toward the Publication of Research Results by Their Researchers in Academic Societies



Source: Science and Technology Agency "Survey of High-tech Researchers and Engineers (1991)"

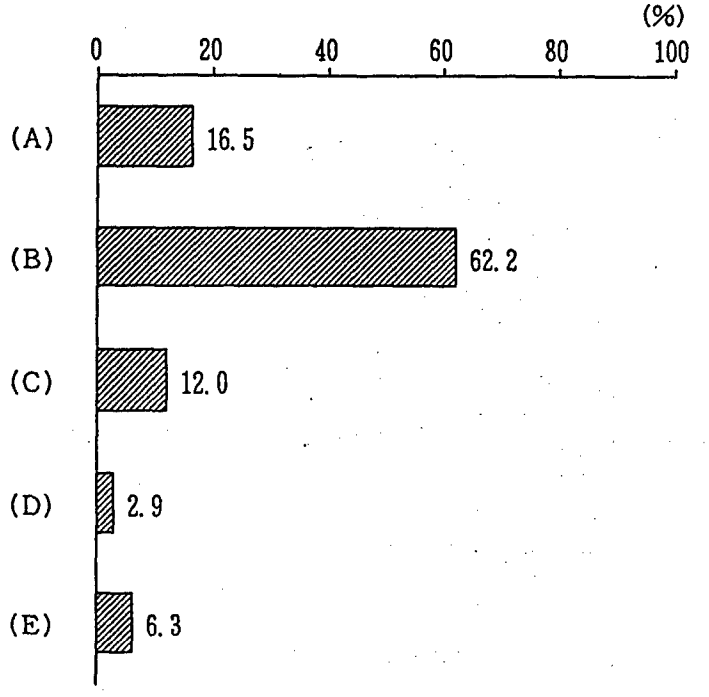
Section 4. Common Sense of Values and Rules to Support Globalization of Scientific and Technological Activities

1. The Need for Common Values and Rules

The scientific and technological environment surrounding Japan suggests that international tension is unlikely to disappear in future. As it is, Japan must continue its efforts to seek international understanding and harmonization. (Figure 42)

Facing serious issues such as deterioration of global environment, nations must share a common philosophy, while developing science and technology. As such values and rules common to all nations are very important to support globalization of scientific and technological activities, Japan should actively participate as a member of the international community in establishing them and taking initiatives as appropriate.

Figure 42 Future International Circumstances around Japan in the Field of Science and Technology

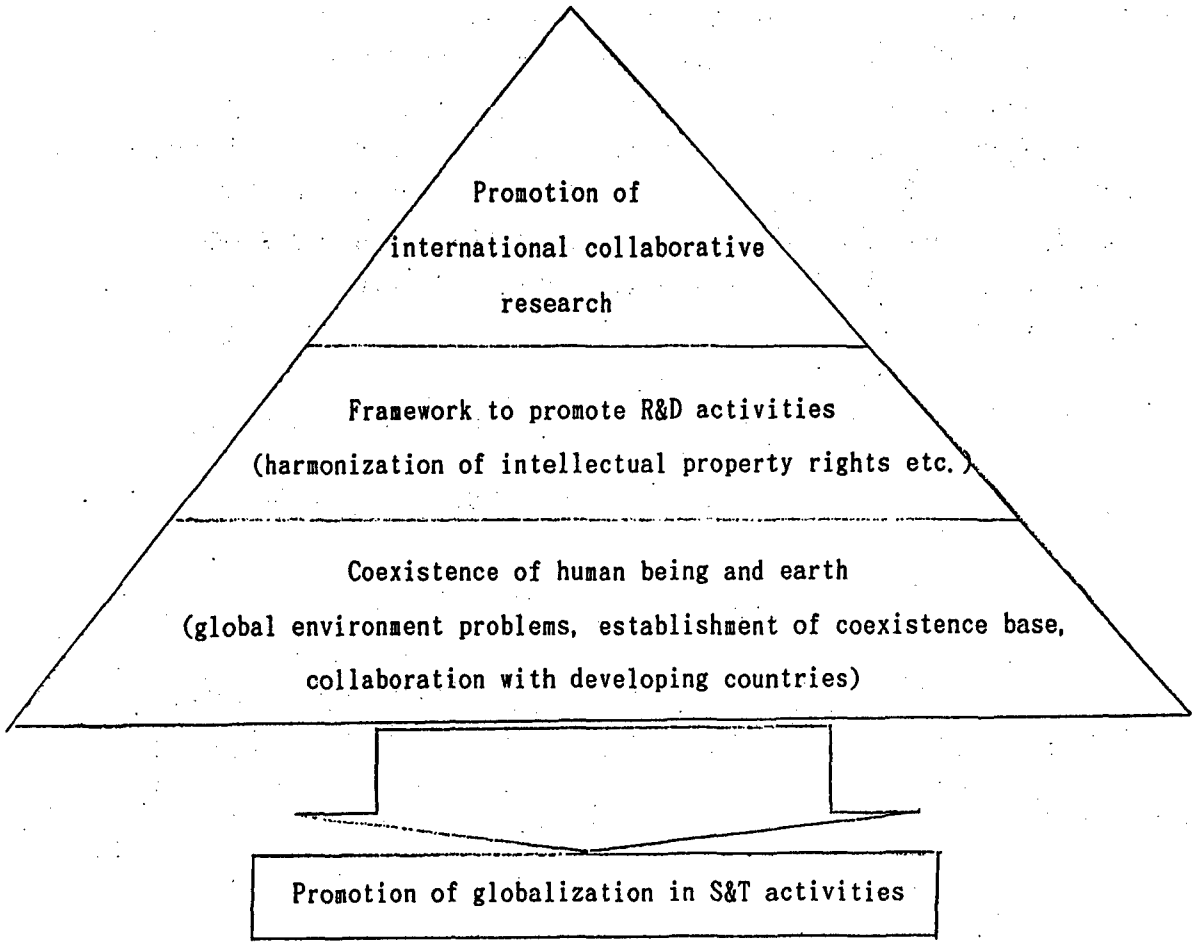


(A) Each country seeks to strengthen science and technology ability, thus international tension (technology friction) will be growing.
(B) Efforts to grope cooperation continue, thus international tension will continue locally and intermittently.
(C) International cooperation will increase, thus international tension will be eased.
(D) Japan, U.S. and Europe make economic blocks, thus international cooperation will decrease and international tension will be eased.
(E) Others

Source: Science and Technology Agency "Survey on Private Enterprises' Research and Development (1991)"

These common values and rules may be conceived and developed in the context of "successive coexistence of human being and the Earth", "similar framework for the conduct of R&D" and "development of international collaborative research". The issue is very complex, but we need to make sure that the values and rules to be derived are rational and transparent so that they are acceptable to all nations concerned. (Figure 43)

Figure 13 Common sense of values and rules to support the globalization of S&T activities



2. Coexistence of "Human Being and the Earth"

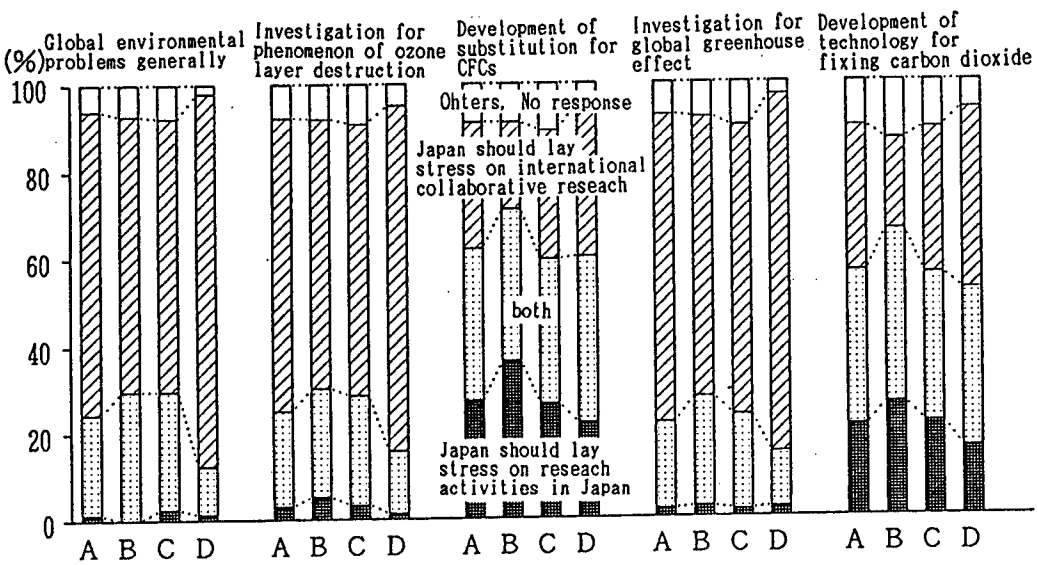
(1) Global Environment Issues

To cope with the global environment problems, science and technology should be regarded as ways and means for coexistence fo Human being and the Earth rather than the driving force of economic development or cultural activities aimed at pursuit of truth. As such, research and development concerning the global environmental problems must be basically cooperative. Public research institutions of all countries need to take a strong initiative to promote efficient cooperation among the nations to resolve the global environment problems.

It is also a responsibility of naitons to establish evaluation method of influences and to conduct it, for the case such as the introduction of newly developed materials.

Concerning scientific and technological activity to global environment issues, Japan should cooperate to the international efforts in those comprehensive areas such as destruction of ozone layers, greenhouse effects. At the same time, Japan should try to make specifically the best use of domestic resources to develop substitutes for CFCs or technology needed for fixation of carbon dioxide. (Figure 44)

Figure 44 Way of R&D concerning global environmental problems



A. Total
B. National research institutes
C. Universities and Colleges
D. Private Corporation

Source: Science and Technology Agency
"Survey of High-tech Researchers and Engineers (1991)"

(2) Safeguard of Living Environment

Values of all things created by mankind, including science and technology, depend on how these things are utilized. Globalization

of scientific and technological activities must proceed in line with our determination and efforts to safeguard our own living environment which constitute common obligation to all people.

We must continue to ask those countries who have not yet concluded the Treaty on the Non-Proliferation of Nuclear Weapons and the Safeguards Agreement to do so. We also request all countries to adopt the international guidelines for control of missile-related technology export. Japan should raise a strong opinion in favor of amendment to the agreement prohibiting biological warfare in order to make sure that biological and chemical technologies are not used for military purposes.

(3) Cooperation with Developing Countries

Japan should promote technical assistance under the official development assistance (ODA), direct investment in manufacturing sectors and exchange of researchers and technical experts with those developing countries in due regard of their desires to stand on their own feet.

3. Common Frameworks for Promotion of Research and Development

(1) Relationship of R&D Activities of Private Corporations with the Government

In comparison with other advanced countries, it is clear that the share of governmental funding in total research spending by private sector is extremely small compared to those of other countries. (Table 45)

With regard to government-sponsored or government-supported programs, there is no indication that Japan is ahead of other advanced countries in doing these efforts. (Table 46)

These data suggest that the outstanding strength in competitiveness of Japanese private corporations is not due to official support of the government to their research and development, but to the strenuous effort of these corporations themselves.

Table 45 Flow of Government Research Fund into Industry by Selected Countries

Japan (FY1989)		U.S. (FY1990)		Germany (FY1989)		France (FY1983)		U.K. (FY1988)	
Amounts	Share	Amounts	Share	Amounts	Share	Amounts	Share	Amounts	Share
¥100million	%	¥100million	%	¥100million	%	¥100million	%	¥100million	%
1,028	1.2	71,300	33.0	4,526	11.5	3,646	22.4	3,888	16.5

Note) Share shows percentage to the whole industry R&D expenditures.

Table 46 Some Examples of Government-sponsored or Government-supported Programs Relating to Private Corporations in Japan, the U.S. and Europe

Japan	Cooperative Development of Industrial Technology etc. (JRDC) Large-scale Project Program Next-generation Fundamental Industrial Technology Research and Development Program Japan Key Technology Center Bio-oriented Technology Research Advancement Institution Adverse Drug Sufferings Relief and Research Promotion Fund etc.
U.S.	High Performance Computing and Communications Advanced Manufacturing and Materials Semiconductor Manufacturing Technology (SEMATECH) Advanced Technology Program (ATP) Engineering Research Centers GaAs IC Program etc.
Europe	Framework Program (ESPRIT, RACE, BRITE etc.) EURECA Plan etc.

Source: Science and Technology Agency

Number of foreign researchers and corporations participating in research and development programs supported by the Japanese Government is increasing. Its further development is desirable.

(2) Intellectual Property Rights and Standardization of Industrial Products

As importance of intellectual property rights is gaining recognition throughout the world, Japan devotes itself hard to harmonize the system of intellectual property rights.

For the domestic patent system, the government is making efforts to reduce the time required for examination and other procedures by increasing more patent examiners and introducing the paperless system.

International standardization facilitates exchange of goods and information across borders. Thus, the development of standardization is very important as the basis of international cooperation in the sphere of scientific and technological activity, and for this reason, Japan is actively involved in developing international standards.

4. Promotion of International Collaborative Research

(1) International Collaboration

Broadening of inter-disciplinary research activities is stimulating international collaboraive research efforts.

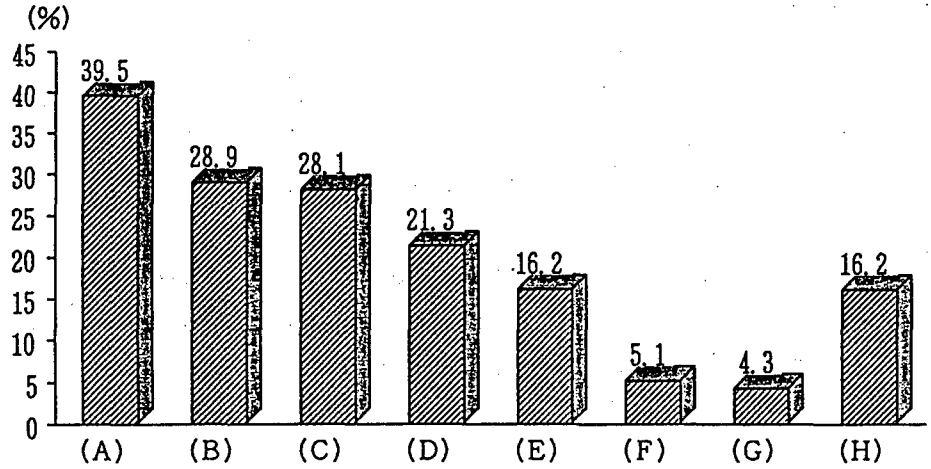
Many experts are of opinion that such international cooperation in research is necessary in order to adopt different approaches in research to compare results, or because they are unable to find domestic partners to carry out research. (Figure 47)

(2) Megascience

With regard to megascience, the majority of Japanese researchers think that while international cooperation is desirable, it should have little adverse impact on other fields of research (so-called small science). (Figure 48)

For specific projects, it is important to make sure that full exchanges of ideas be made among the international partners from the very beginning of conceptual stage.

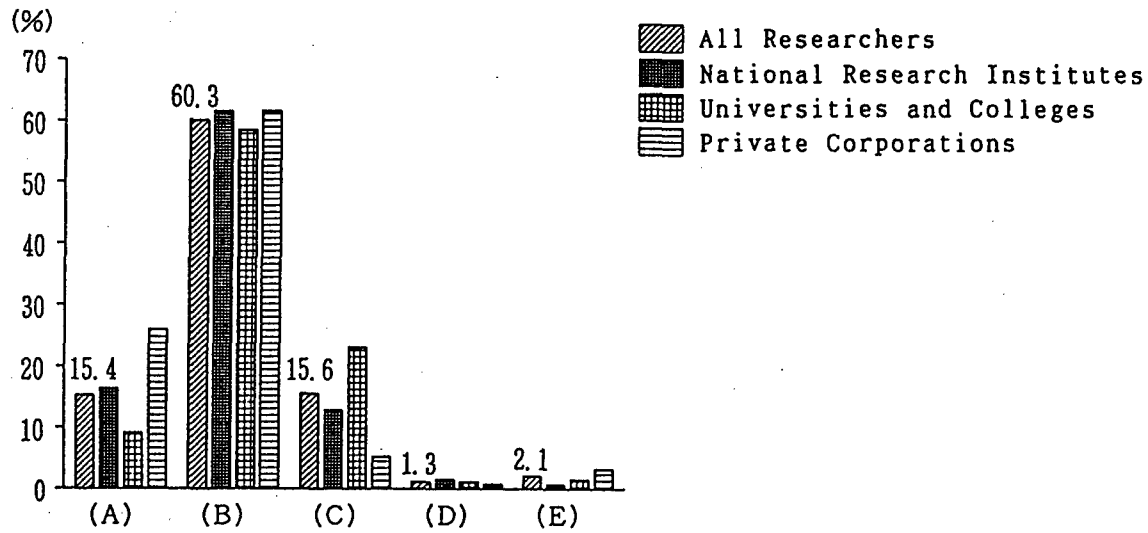
Figure 47 Reasons for Collaborative Research with Overseas Researchers



(A) To compare results of researches in different approaches
(B) No partners in Japan
(C) To compensate knowledge and technology each other
(D) To share costs and manpower
(E) To dissolve geographical restriction (ex. share of observation points)
(F) Other purpose (No particular merits to note)
(G) To advance the standardization of products
(H) Others

Source: Science and Technology Agency "Survey of High-tech Researchers and Engineers (1991)"

Figure 48 Researchers' Attitude toward Megascience



(A) Should cooperate positively, even if there will be a little influence to other research areas in fund distribution.
(B) Cooperation is desirable, but there should be little influence to other areas.
(C) No need to cooperate positively, if there will be influence to other research areas.
(D) No need to conduct international cooperative research in Megascience.
(E) No opinion

Source: Science and Technology Agency "Survey of High-tech Researchers and Engineers (1991)"

A long-term commitment of participating countries is essential for successful accomplishment of international collaborative research projects.

Chapter 3. Our Expectation for Science and Technology at the Critical Juncture in the Global History - Future Tasks and Prospects for Japan

One of the most important factors contributing to the end of the Cold War should be the tremendous development of information and electronics technology. In general, science and technology are indispensable for today's society, of which our dependence on them to cope with global environmental issues is a typical example. Under these circumstances, it will be most opportune and desirable for Japan to take an active role in the domain of science and technology.

However, in comparison with other advanced countries, there is a marked lack of balance between Japan's weakness in basic research and its strength in technologies represented by high technology products. Japan is now compelled to reflect on this fact and determine which course of action should be taken in the long term. Ever since the second half of the 19th century, Japan depended much on science and technology imported from Europe and the United State. For this reason, even if there should occur protectionist attitude in view of the steady advance Japan had been making in the domain of science and technology, it should not deter us from making further efforts toward the globalization of scientific and technological activities, because it is essentially a "plus sum game" by which all can benefit in the long run.

For this purpose, it will be necessary for us to succeed in two things: firstly, to become a well-accepted member of world research community by harmonizing domestic activities with those in other countries, and secondly, to play an active role for establishing common values and rules to support the globalization or science and technology activities.

In order to achieve the first task, we need:

- To improve the level of research activities in the public sector;
- To secure sufficient number of qualified researchers;
- To improve research environment, and
- To improve infrastructures needed to accept more researcheres form aborad.

Accomplishment of the second task regarding common sense of values and rules, there is a need for an international consensus on the following:

- Science and technology must serve to harmonious coexistence of mankind and the earth;
- Researchers and corporations of each country are abele to work within the common framework regarding participation to research projects sponsored by national governments system of intellectual property rights etc.; and
- Approach to be taken to ensure cooperation for international collaborative research including megascience.

Also, because all countries are becoming more and more inter-dependent in terms of science and technology, good communication and mutual understanding between the countries are of paramount importance for the international community including Japan, if we want to establish common sense of values and rules for carrying out R&D, or to implement strategic policies. It will be very helpful, for instance, if Japan, the United States and European countries can conduct a joint survey on their respective levels of science and technology, because this will allow the participating countries to have a common and objective understanding of the present situation. Such an understanding will be most useful for officials of these national governments to establish their policies and to exchange opinions and views each other. This kind of collaboration can contribute to make science and technology Policy of each country more internationally understandable and transpanent. This steady effort can lead to avoid unnecessary conflict between the nations in the future.

Lastly, it should be stressed that Japan has an obligation to increase its participation and contribution to the international efforts in resolving through its scientific and technological means those global issues with which mankind is faced at this critical juncture.

- END -

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