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[This paper, entitled 'White Paper on Science and Technology 1989--New Developments in Japan Science and Technology in the New Era of Heisei', and sponsored by the Science and Technology Agency, is "an informal summary, prepared in March, 1990 in cooperation with the Foreign Press Center."]

CONTENTS

Introduction

Japan attained its goal of securing independent technological capability in a number of fields in the 1970s. Since then, efforts to promote more creative R&D were stressed and made. As Japan enters the 1990s, it is necessary for our country, a nation which, compared with the rest of the world, possesses very high levels of science and technology, to seek its own, new ways to further advance science and technology and satisfy the needs of our economy and our people. At the same time, we need to nurture new science and technology which will contribute to the further development of the world economy as a whole.

In response to these circumstances, this year's White Paper on Science and Technology deals with the theme, "New developments in Japanese Science and Technology in the New Era of Heisei," by considering how Japan's science and technology will progress and what new developments will be achieved in the midst of a variety of social and economic changes both in Japan and abroad. The white paper presents structural analyses of a number of aspects of the current state of science and technology in Japan from the viewpoint of its future prospects. These include: the improvement and future development of technological capability as a result of the superior performance of Japanese industry, changes and new requirements in the role of the public sector, personnel problems, and regional development in science and technology. It also examines the radical changes taking place in international science and technology and Japan's response to them.

The text of the white paper is composed of Parts 1, 2, and 3. Part 1 examines the relationship between science and technology and economic activity in society, and at the same time, analyzes and clarifies future issues regarding the topics mentioned above: the role and performance of industry and government in science and technology, and changes in science and technology around the world, and Japan's response to them. As in previous years, parts 2 and 3 are a summary report on 1988 science and technology focused on activities and government policies. This report is primarily a summary of part 1.

Part 1. New Developments in Japanese Science and Technology in the new era of Heisei

Chapter 1. Progress and new developments in Japanese science and technology

1. Japanese science and technology: background and present status

(1) Japanese science and technology which supported economic and social development and continues to leap ahead

(Science and technology as the major tool in response to changes in the social and economic environment)

Having rapidly caught up with Europe and the United States, Japan faces a new era of internationalization, population aging, and the diversification of values, and it must now work to share the international responsibility which fits its wealth and create a new economic structure designed to divert the fruits of economic growth to the improvement of the quality of life for its people's real richness. Science and technology and the innovation based upon them are playing an important role in these tasks. Prior technological progress in Japan has characteristically made a significant contribution to the country's relatively high rate of economic growth. This trend has become more pronounced in recent years, and Japanese growth is being largely driven by science and technology.

Japanese science and technology has been progressing satisfactorily, particularly since the early 1980s when research expenditures began to grow much faster than GNP. This is due to the fact that the industrial sector is very active to invest in research and development, and is responding positively to trends such as the shift to high value-added production. It also indicates that companies have begun to aggressively expand their research and development activities to satisfy their own technological needs, and are switching to a self-supporting science and technology structure in order to independently discover the seeds for long term growth.

Table 1 Histrical Overview of Science and Technology in Japan

	1945－1965	1965－1975	1975－1985	1985－
Social economic situations	•Post-war economic recovery •Income-doubling program	•Transition to open economy •Environmental problems •Oil crisis	•International friction •Stable growth •Nature society	•Expansion of domestic demand •Global environmental issues •Borderless economy
Demands on science and technology	•Narrowing gap between Japan and advanced nations •Development of heavy industries and pursuit of economy of scale	•Development of knowledge-intensive industries		•International contribution
Scientific and technological challenges	(Import of technologies•••) (Improvement of production/processing technologies)	(Establishment of independent technological capability) (Environmental pollution control technology)	(Repeated emphasis on creativity) (Energy•Natural resource technology (Technology transfer to overseas)	(Self-supporting science and technology) (Global environment protection research)

Chart 1 Trends in R&D Expenditures and GNP (in real terms)

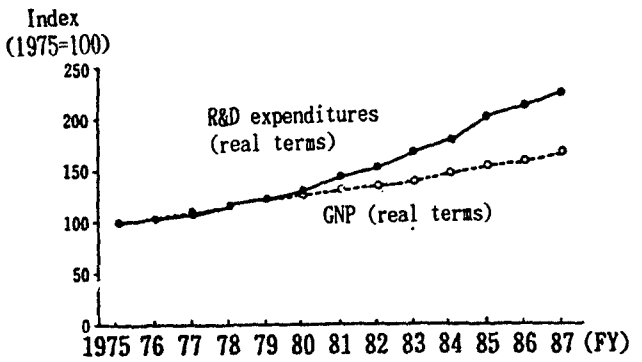
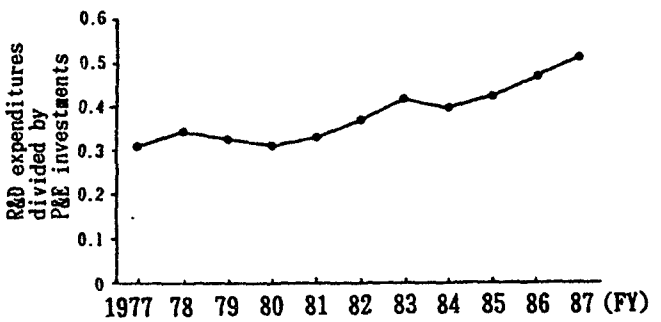


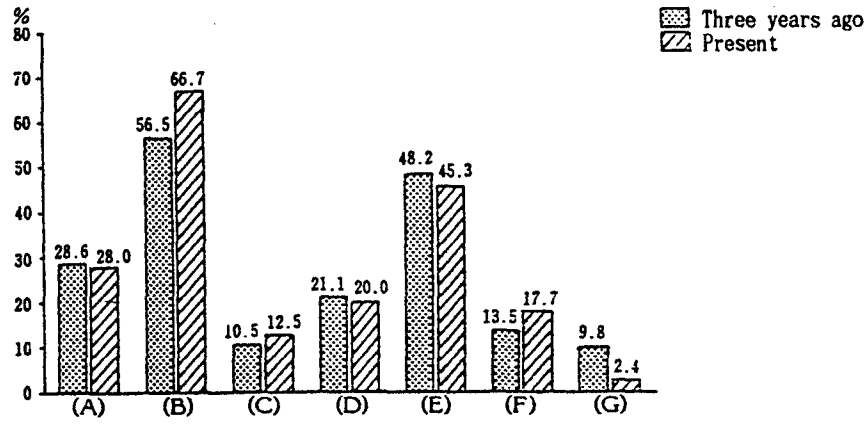
Chart 2 Trends in Ratio of R&D Expenditures to Plant and Equipment Investments



(Corporate management and research and development)

Many companies selected "strengthening research and development" (66.7%) as the most important aspect of corporate management (This survey was made by STA September, 1989. 879 major manufacturing firms responded). In second place was "increasing the added value in our existing business areas" (45.3%). There is deep awareness that in the midst of ongoing restructuring of the economy, research and development and related activities are extremely important in Japan. This growing consciousness of the importance of R&D is apparent in the fact that even in the areas of plant and equipment investment and employment, companies consider their research and development division to be a top priority. Under these circumstances, it is forecast that almost all private companies will continue to intensify the R&D expenditure and human resources devoted to research and development.

Chart 3 Policies in Japanese Corporate Management



A: Business diversification, branching out into other businesses
B: Strengthening R&D activities
C: Globalization including establishment of overseas production bases
D: Strengthening marketing research
E: High value-added products in existing business fields
F: Strengthening total business capabilities as a corporate group including affiliated firms
G: streamlining including withdrawal from non-profitable fields

(Changes in the role of government and an appropriate response)

In the last few years, research and development activities in industry have expanded by leaps and bounds, and the role of the national government or the public sector in research and development activities seemed declined in relative terms. But while on one hand the social structure has been radically transformed, Japan, now a leading nation in the international community, is also called upon to carry out its international responsibilities. So in order to respond correctly to the altered environment of this new era, it still has a major role to play in science and technology: conduct basic research, train researchers and engineers, establish a research environment, and deal with social issues.

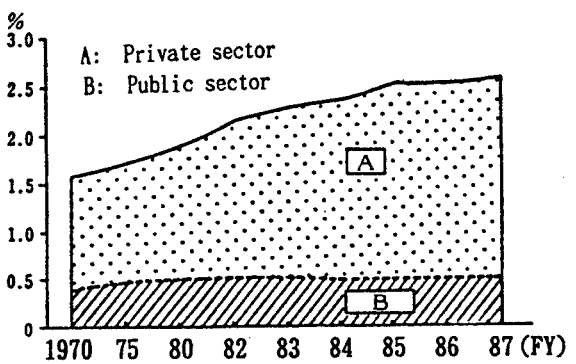
(2) The fundamentals of Japanese science and technology and international comparisons

-Research expenditure-

As a percentage of GNP, Japan's investment in R&D has already reached an internationally high level at 2.8%, roughly equal to that of West Germany, and is rapidly drawing close to 3%, a level not yet reached by any large industrialized

nation. But Japan's research expenditure in absolute number (OECD purchasing power parity) is far behind that of the United States (only 38% of what the U.S. spends). A breakdown of Japanese research expenditures as a proportion of GNP shows that while the private sector bears a large proportion of the funding, the government share is only 0.5% (In U.S. and major European nations, it is 1% or more).

Chart 4 Trends in Ratio of R&D Expenditures in GNP (by sector)

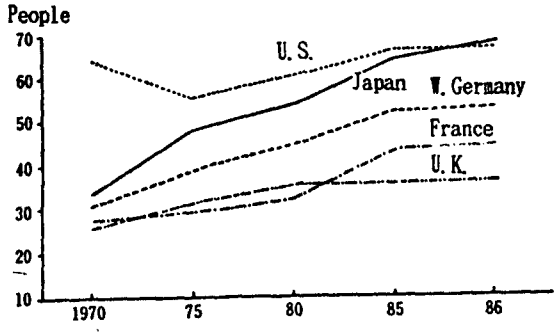


-Research personnel-

The number of researchers in Japan has been growing more than 5% annually for the past 5 years. Statistics on the affiliation of Japanese researchers reveal that 290,000 work in industry, 130,000 are in universities, and 30,000 are employed by public research organizations, and that the university's share of Japan's researchers is higher than its share of the country's research expenditure. An international comparison of the distribution of researchers shows that the universities' share is high in Japan and France, that in many European countries a high proportion of researchers are in government research institutes, and that the countries with a high proportion of researchers in industry are the U.S. and West Germany.

Japan has the highest number of researchers per 10,000 workers, a reflection of the industrial sector's positive attitude towards research and development.

Chart 5 Trends in Researchers per 10,000 labor force



-Patent applications and publication of papers-

The number of patent applications filed within Japan continues at a high level, in excess of 300,000, and there has been a spectacular leap in Japan's share of patents granted in the U.S. where the patent applications are made for the world's most important research results. These facts are an evidence of Japan's solid research and development structure, and of its advanced technological strength.

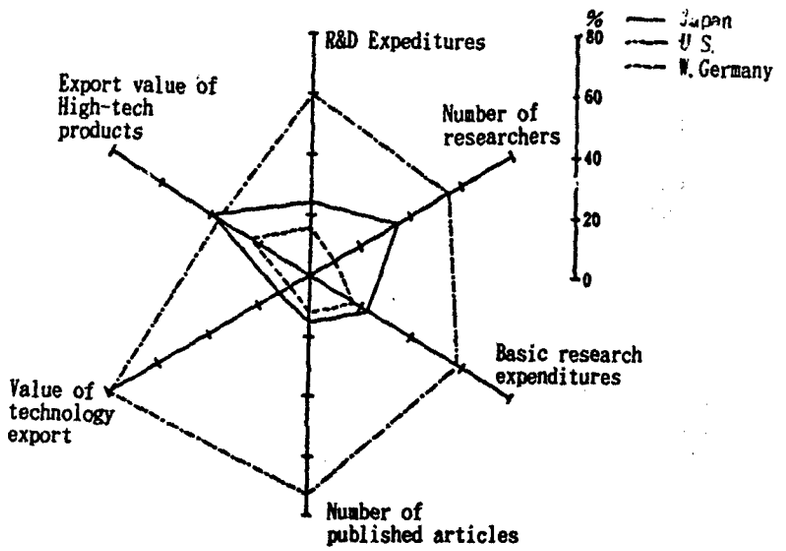
There are 220,000 papers published in Japan (according to 1988 JICST records), and 22,000 are published in influential foreign journals (1984 OECD survey). The international share of Japanese published papers, an index of a country's scientific capability, is still less than 10%.

-Trade in technology and high-tech products-

The United States is overwhelmingly dominant in technological trade, with almost all other major countries importing more than they export. The trade balance ratio (Ex/Im) in high-tech products which utilize research result is 5.7 for Japan, a reflection of its technological capability in manufacturing.

These facts show that Japan is superior in technology and manufacturing, but is somewhat weak in science which could be viewed as background of technology. The following chart summarizes the S&T situation in Japan, the United States, and West Germany.

Chart 6 International Comparisons of Major Science and Technology Indicators



Notes: Figures indicate percentage in total of three countries

2. Progress and expansion of research and development activities in industry

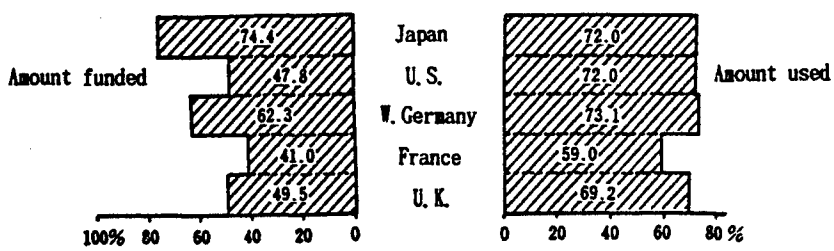
(1) Development toward a strong research and development structure

(Japanese industry's aggressive approach to research and development)

Japanese industry demonstrated "superior adaptability" in the face of the two oil crises and pollution problems which occurred in the 1970s, and has continued "responding positively" to trade friction with the U.S. from early 1980s, and to the strong yen in the past 4 years. Science and technology played a major role in the superior performance of Japanese industry as it grappled with these problems (in the last decade, research and development expenditure has risen 2.5 times in real terms), and further active research and development is under way to keep its performance in the future.

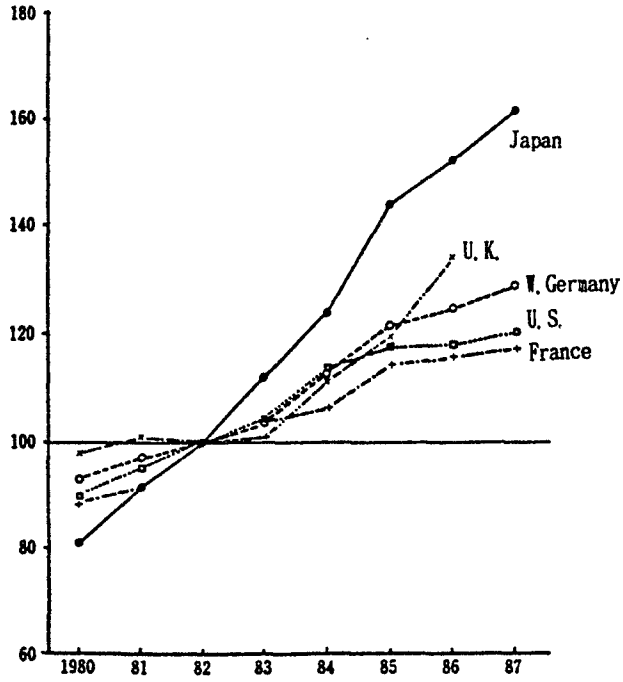
A comparison of industry's share of total research expenditures in the major nations shows that its share in terms of funding, is 74.4% in Japan, much higher than in other countries. This indicates that unlike the United States and

Chart 7 Proportion of R&D Expenditures Funded by the Industrial Sector in Major Countries



other nations where companies are dependent upon the government for a great deal of the money they spend on research, Japanese industry finances their research with their own money. In addition, the actual amount of money spent on industrial R&D is growing much faster in Japan than in other countries. Research expenditures borne by industry in Japan come to more than 80% of the total industry funding in the U.S., and have reached 1.3 times that of the total for the three major European nations.

Chart 8 Trends (Index) in R&D Expenditures (in real terms) funded by the Industrial Sector in Major Countries



Note: 1982=100

(Continued active R&D investment by industry in the future)

Japanese companies whose total R&D expenditure is less than 2% of the company's total sales are about 50% of 879 respondents in 1989. If spending goals set 5 years from now are met, the proportion of companies' R&D spending less than 2% of their sales will drop to below one-third, and there will be significant increases in the number spending 4% or more.

Many high-tech companies, electronics firms for example, invest more in research and development than on plant and equipment. Furthermore, there is a tendency for companies to stress items related with research and development among plant and equipment investment.

Based upon these facts, it can be concluded that in industry, research and development investment will continue its steady growth, and the powerful research and development structure will be maintained.

Chart 9 Company's R&D Funds as a Percent to Net Sales

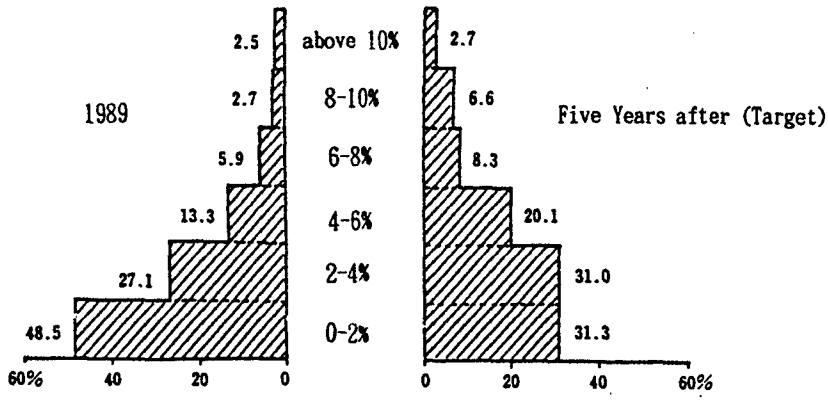
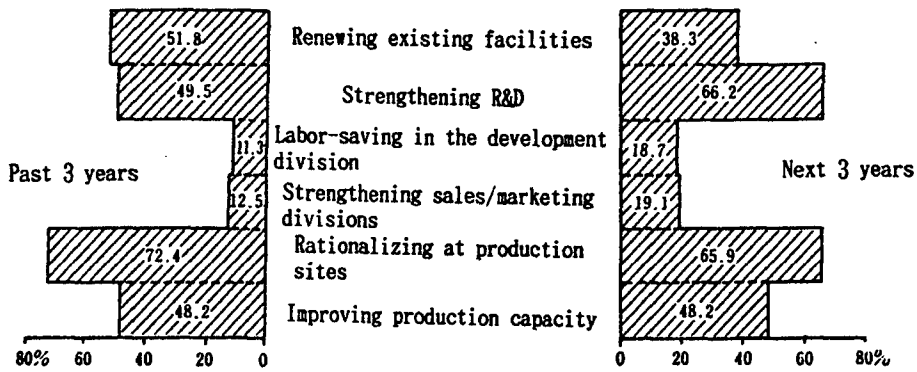


Chart 10 Priorities of Plant and Equipment Investments in the Manufacturing Industry

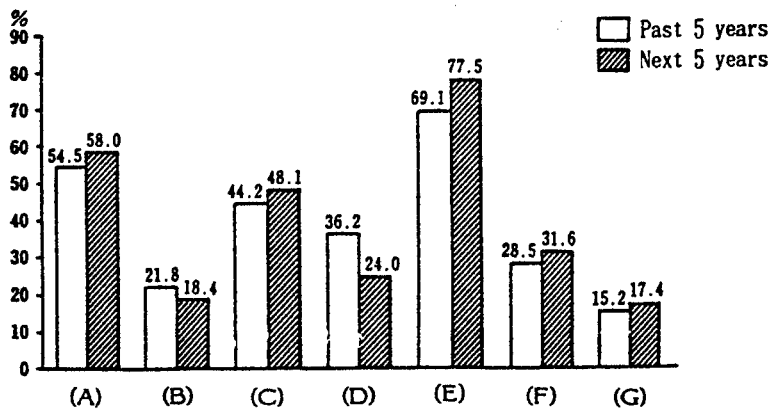


(2) Superior performance and adaptability to more sophisticated needs

(Tackling research and development with a deep awareness of marketability)

The most effective approach to advancing research and development in industry is viewed to stress marketability. But there is a growing tendency to emphasize basic research which aims at independently seeking technological seeds and research for expanding business opportunities in the future.

Chart 11 Source of Origin for R&D Themes



A: Researcher's own ideas
B: Research results anounced outside
C: Requests/feedback from development division
D: Request/proposal for improvement from production division
E: Customer needs relayed by marketing division
F: Directions from top management (top-down)
G: Social needs (energy-saving, etc.)
Note: Multiple responses
Source: Science and Technology Agency "Survey on Private Enterprises' Research and Development" (1989)

When picking up a theme for research and development, they gather information from many areas, placing particular weight on data concerning consumer needs from the marketing department, concepts created by the researchers themselves, and requests from the development division. Thereby efforts to intensify product innovation as well as process innovation are being made.

(Utilization of advanced technology to respond to the need for high value-added)

With price competitiveness of their product weakened by the strong yen, Japanese companies have been forced to conduct research and development to create products with higher value-added. Particularly a number of firms are working to create more value-added products by concentrating on advanced technology. They are attempting to generate greater added value by conducting research and development on advanced technology, primarily to develop products incorporating advanced technology and revolutionary products.

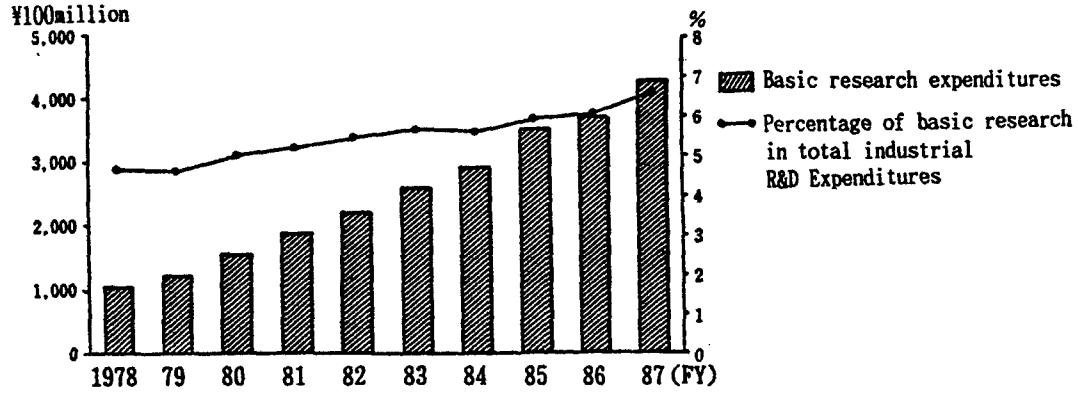
(Concentration of research content)

The largest share of total research investment is made in the communications, electronics, and electrical instrument industries, the only areas in which research investment has been growing significantly in the last few years. This means that research investment is becoming more concentrated in the electronics field. There is also a tendency for companies to carry out research and development on similar topics. This concentration of research and development has created a cycle in which technological development competition intensifies and superior products appear on the market faster. In addition the market benefits from a synergetic effect, as development in many companies expand the market opportunity and they develop the better product mix to consumers, thus contributing greatly to the economy.

(Undertaking basic research)

Research and development in Japanese industry is becoming increasingly long term oriented, and there is a trend to initiate long term development programs with basic research. The proportion of funds that companies spend on basic research (6.6% in 1988) has been on the increase for the last few years, indicating that industry is putting more emphasis on this area of research. However most of the basic research

Chart 12 Trends in Investments in Basic Research by the Industrial Sector



being carried out at the present time is undertaken for a certain framework of goal, for obtaining scientific knowledge related to each company's area of business, and/or for securing the base for long-term research and development. However, in specific fields industry is being counted on to carry out full scale basic research, and it is necessary to create an policy and corporate environment which enables it to continue without interruption caused by changes in the economic conditions. In addition, Japanese companies are

aggressively undertaking restructuring programs intended to maintain their growth ability, where research and development is playing a vital role in supporting these efforts.

(3) Technology in an increasingly competitive environment

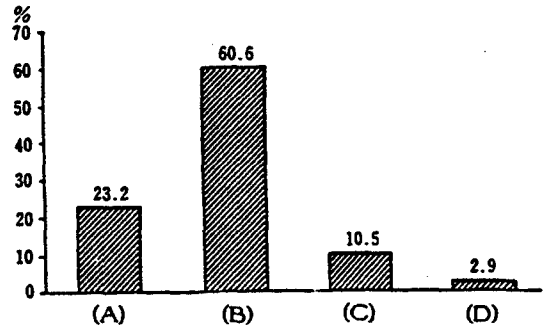
(Intensified competition and technological strength of Japanese industry)

Four companies out of five view that technological competition in the domestic market is further intensifying. Sixty percent of companies also express the view that technological competition is intensifying in overseas markets as well. In the domestic market, the main factor of competition is between firms in the same industry, while in the overseas market, the major cause is an strengthing in competitiveness of Asian companies in the NIEs and European and U.S. companies as well as competition among Japanese companies.

It is considered that fierce technological development competition causes an interrelation in which product cycles as well as technology obsolescence are accelerated, and that this in turn sets off further competition.

Consequently Japanese companies have acquired great technological strength, and more than 80% of them now believe that it is equal or superior to the technological level of the U.S. or European industry.

Chart 13 Self-Assessment of Japanese Corporations' Technical Capabilities



A: Highest level in view of international standards
B: Roughly equivalent to major corporations in the U.S. and Europe
C: A little below U.S. and European standards
D: Inferior in view of international standards

3. The role of the public sector and new developments

(1) Changes in demands on the public sector and its role

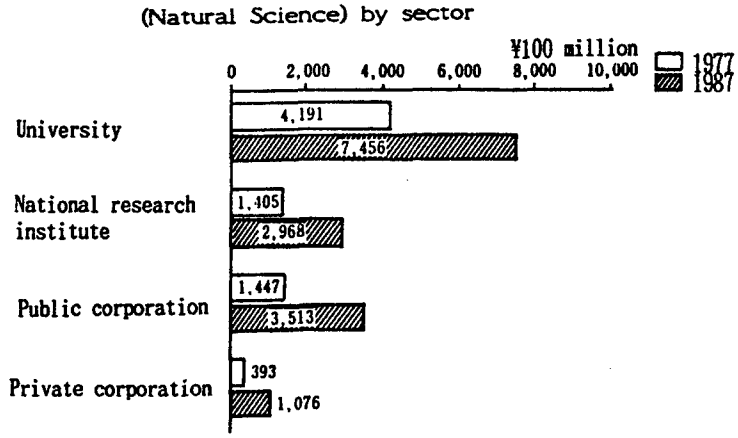
(Changes in demands)

The remarkable progress of Japan's science and technology has brought with it radical changes in the role the public sector is required to play. Ten years ago (when the government's share of the countries R&D expenditure peaked) there was a fervent call for the development of indigenous technology, and the government directly supported industry's efforts to promote development and utilization of advanced technology. Such era was over, and now the government is being called upon to fulfill obligations appropriate to the nation's position in international community. Under these circumstances, the government is expected to make best efforts to promote basic research, especially at academic institutions, make a greater international contribution for expansion of world intellectual stock or for technical cooperation to LDCs, and domestically to respond to the people's need for an improvement of quality of life. It is also expected to cultivate the ability on the part of government to cope with rapid changes in the economy and society.

(Resource situation)

Affected by financial restraints, the nation's science and technology budget has increased an average of 4% per year in nominal term (same rate of GNP growth) for the last 5 years, and reached 1.8 trillion yen in 1989. But owing to the high rate of growth in science and technology activities in

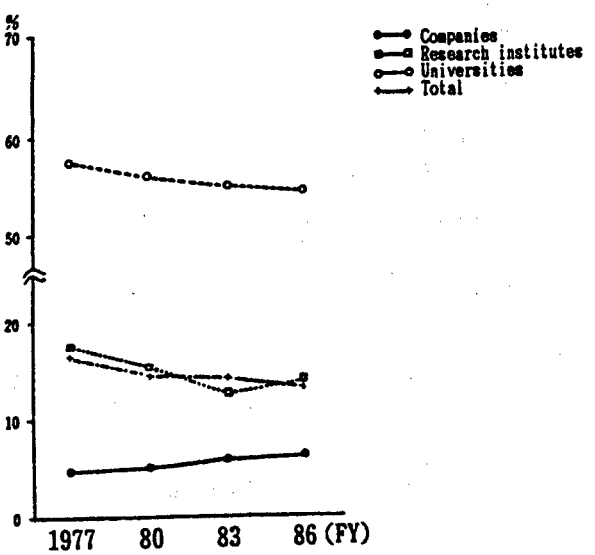
Chart 14 Distributions of the Government R&D Expenditures (Natural Science) by sector



industry, the government's share of total spending in Japan continued to fall for the last decade.

An analysis of research expenditures by type of research shows that the proportion devoted to basic research has also tended to fall for the same reason, and this situation needs to be improved. The scale of scientific and technological

Chart 15 Trends in Ratio of Basic Research in total R&D Expenditures by Sector



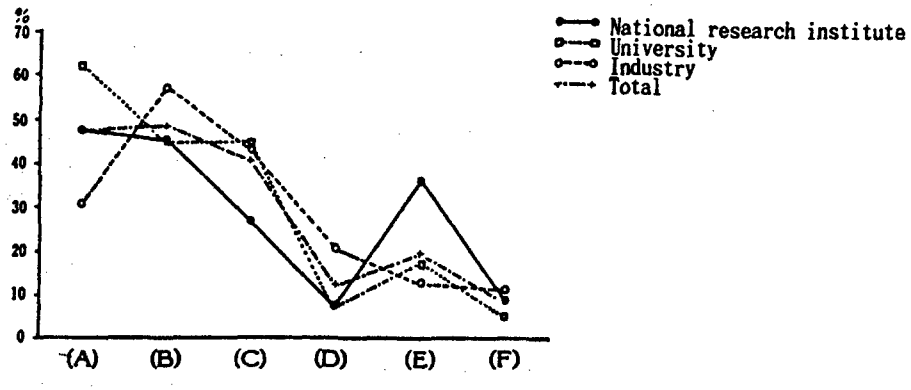
activity in Japan is large. Though, the quantity of research expenditures supplied by, and the number of researchers working in, the public sector both comprise a somewhat low proportion of the total for all OECD nations in comparison with other share of S&T activities. Japanese government investment in R&D is 0.5% of the nation's GNP, about half that of Europe and the U.S. where it is at least 1%. It is expected that the public sector will do more to respond to new demands it must satisfy.

(2) New development in strengthening basic research and making an international contribution

(Substantiating basic research)

Key structural issues related to Japan's overall R&D system are funding and balance of research (the balance between basic research and applied research and development), which is indicated by each of academia, industry and government institutes. It has been fervently pointed out that

Chart 16 Necessary Issues to Promote R&D Activities in Japan (by Sector)

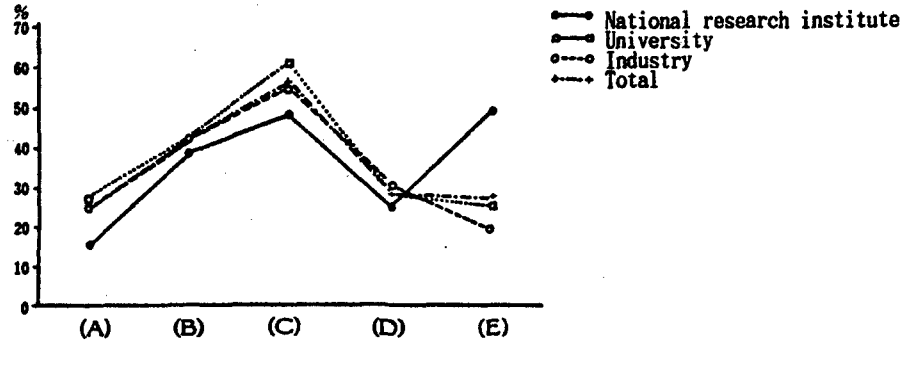


A: Funds
B: Research structure
C: Research system
D: International relation in R&D sector
E: Supply/demand situation of R&D personnel
F: Production of research results

Note: Multiple responses from Japanese researchers
Source: "Survey of High-tech Researchers and Engineers"

there is a shortage of basic research fund and a need to increase government outlays. Also in recent years, research and development tends to be conducted to achieve practical objectives, causing a relative decline in basic research that is intrinsically carried on without a specific application.

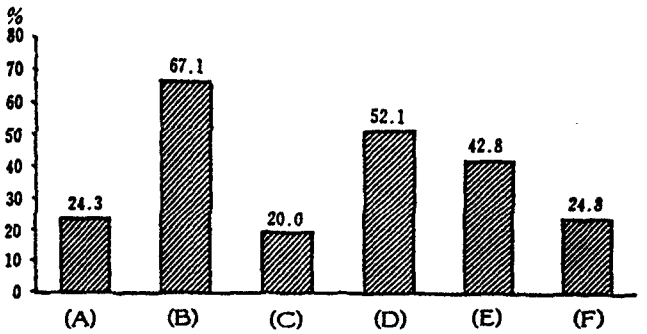
Chart 17 Problems in R&D Funds in Japan (by Sector)



A: Increase of total R&D investment
B: Insufficient government R&D investment
C: Insufficient basic R&D expenditures
D: Improper distribution of R&D funds
E: Spending restrictions
Note: Multiple responses

It seems that this has had a negative impact not only on basic research but on overall S&T activities. There is a pressing need for policies to strengthen the position of basic research: taking steps to enhance systematic funding, creating liberal research system, making research management more flexible, setting up a competitive environment, and evaluating research result properly.

Chart 18 Measures to Strengthen Basic Research

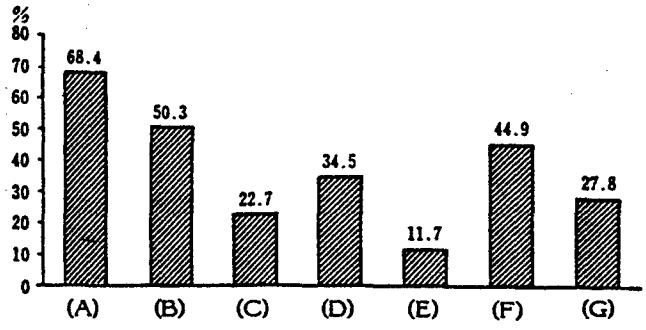


A: Grow up several centers of excellence
B: Promotion of free research system
C: Establishment of qualified R&D facilities
D: flexibility of researchers exchange and R&D management
E: Competitive research circumstances and research evaluation
F: Development of competent research managers
Note: Multiple responses

(Promoting Japan's contributions to international community)

The public sector ought to play a leading role in making contribution to international science and technology. A survey of opinion (opinions were collected from a thousand leading Japanese scientists of various fields) about measures which the government should take to contribute to the international community shows a strong demand that it should play a role in assisting full scale exchange of researchers and international conferences, especially acceptance of foreign researchers into Japan, and in producing more original basic research result of impact.

Chart 19 Necessary Actions for International Contribution in Science and Technology



A: Invitation of foreign researchers for hiring/training purposes
B: Production of basic research results
C: Increase R&D funds for internationaly use
D: Improvement of and open access to sophisticated research facilities
E: Active technology transfer
F: Internationalization of academic societies' activities and support for international conventions
G: Promotion of global R&D activities

Note: Multiple responses

In recent years the government has adopted a number of measures to respond to the country's international responsibility. It has established and expanded a fellowship program for foreign researchers coming to Japan, and set up an organization to assist with exchanges of scientists and engineers. In October 1989, an organization was established in Strasbourg, France, to promote the Human Frontier Science Program, a concrete Japanese contribution to basic research.

But projects of this type, undertaken expressly to make an international contribution, have just begun. It will be necessary to continue to strive to provide ways to make a contribution appropriate to the economic or S&T power of Japan.

(3) The role of governmental research organizations and development of policies to activate them

While the industrial sector is conducting sufficient research and development, the share of research and development performed by public bodies, particularly the share of research expenses borne by the government, is comparatively getting lower. Nevertheless, public research institutes are expected to undertake longer-term research and development, and produce sufficient results from basic research, and have other important roles to play including the establishment of new academic disciplines. During the last

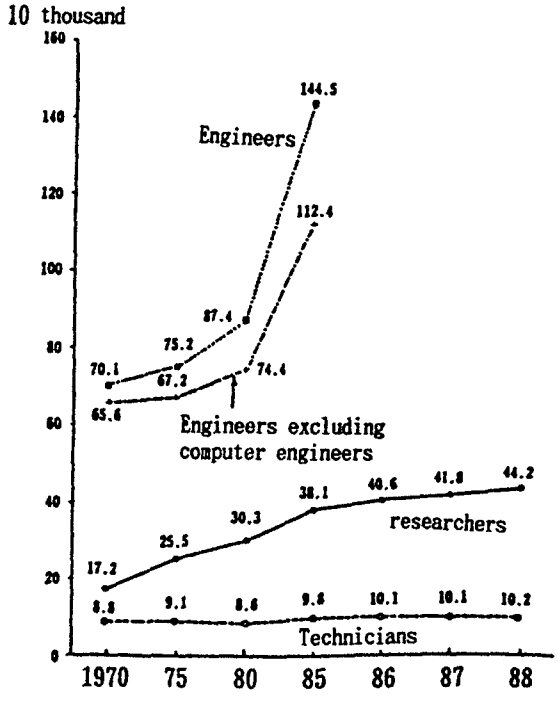
few years, several guidelines were shown to strengthen basic and original research to create the new technological seeds, and the government implemented such policies step by step. According to a survey of the implementation of these policies conducted by the Council for Science and Technology, there are many problems which will be difficult to solve in the short term, aged human resources for example, but in general zealous efforts are being made to achieve the objectives of the policies.

4. An increasingly difficult task of securing enough researchers and engineers

(1) Changes in the numbers of researchers and engineers

The rapid advancement of science and technology in Japan has resulted in a sharp increase in the number of researchers. The growth has been particularly remarkable in industry, and the opening of new universities and university departments has also expanded the number of researchers. The number of engineers also has consistently grown, and since 1980, it has expanded particularly fast. This is not only a result of increases in the number of information processing specialists, but of growth in the number of technical specialists in other fields. Today it is forecast that there will be a continued high demand for researchers and engineers, and it will necessary to smoothly secure them without causing serious shortages.

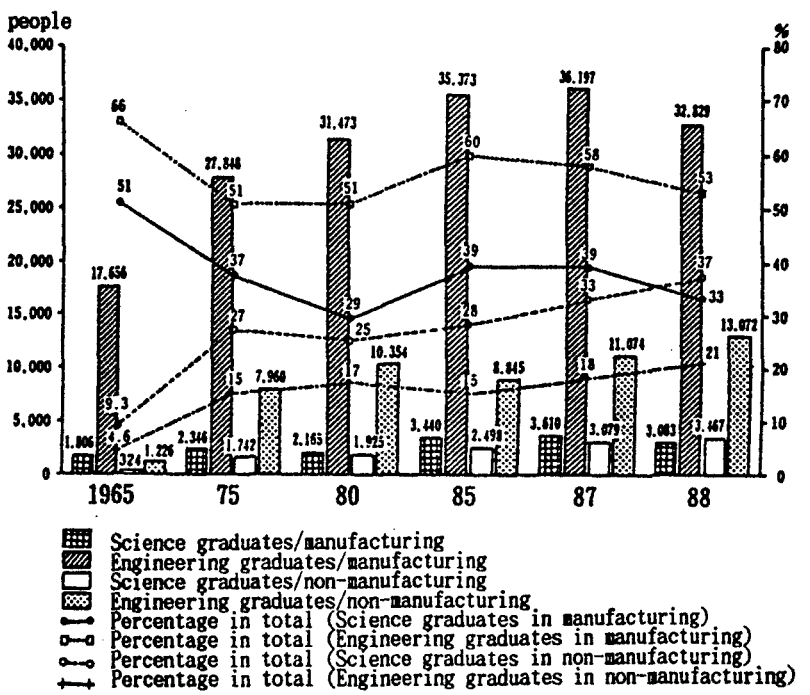
Chart 20 Trends in Number of Researchers, Engineers, and Technicians



(Employment trends among science and engineering students)

In 1988, 110,000 natural science students (including masters and doctoral course) graduated and were employed, its growth rate declining annually. Recently it is pointed out that the increasing share of science and engineering students tend to take jobs outside of manufacturing industries. But a look at figures on the employment of science and engineering students in the manufacturing industries, broken down by academic background, shows that up till 1987, the number of engineering students was steadily increasing, while the number of science students increased more slowly, but in 1988, about 3,400 fewer engineering graduates, and about 500 fewer science graduates were employed in the manufacturing industry. In contrast to this, the number of students getting jobs in the non-manufacturing sector rose between 1985 and 1988. This may indicate a trend away from the manufacturing industry; and there exists pessimism in industry about obtaining sufficient, talented researchers. But the situation changes a great deal every year due to economic circumstances, and for the time being it will be necessary to carefully observe trends in the

Chart 21 Trends in Employment of Science and Engineering Graduates (Manufacturing/Non-manufacturing)



attitudes of science and engineering graduates, and at the same time, devise appropriate policies by both industry and government to guarantee a sufficient supply of researchers and engineers and to attract them as in the past.

Chart 22 Trends in Employment of Science and Engineering Graduates (Finance/insurance)

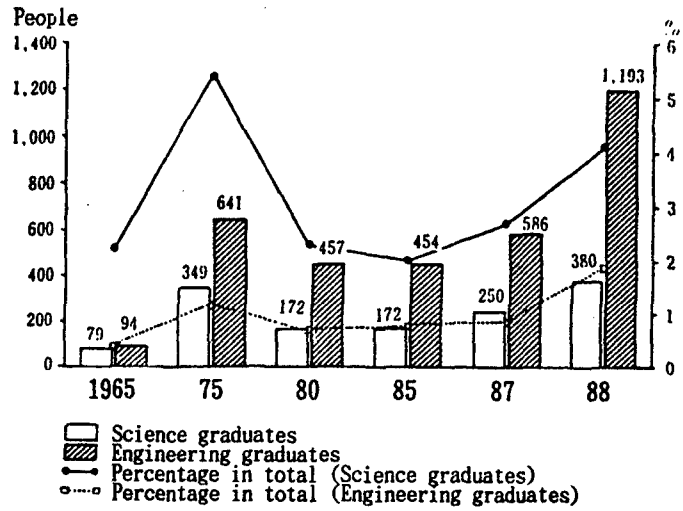


Chart 23 Trends in Sciences and Engineering (S&E) Graduates' Decreased Interests in Manufacturing Industries

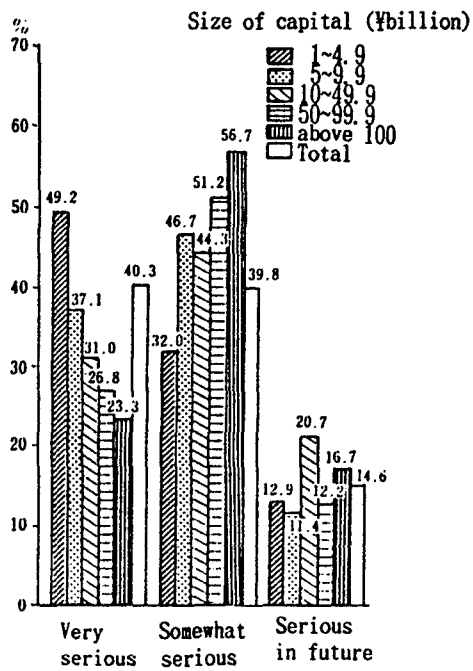
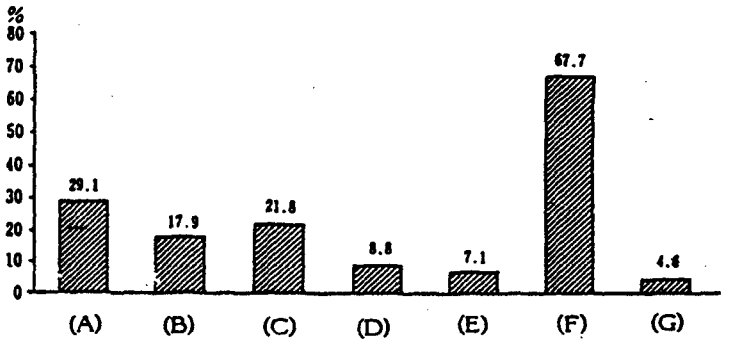
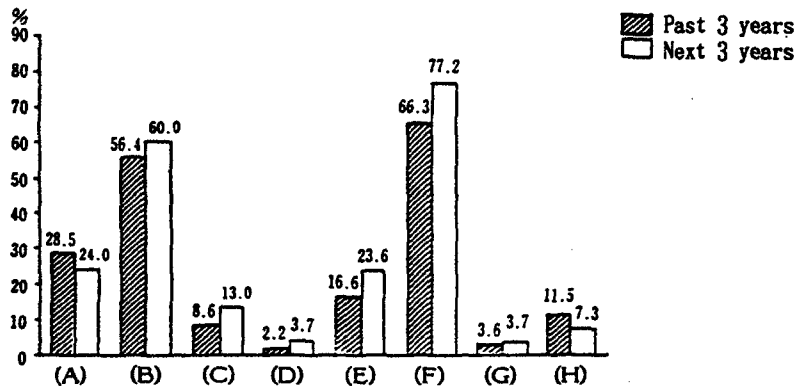


Chart 24 Measures to Recruit S&E Graduates in Manufacturing Industries



A: Improve salary standards and personnel treatment
B: Improve residential conditions
C: Improve working conditions for research activities
D: Establish (or locate) research institute in Tokyo or Tsukuba region
E: Establish committee on S&E graduates' recruitment
F: Promote the introduction of company's (PR) activities
G: No special action for graduates' decreased interests in manufacturing industries

Chart 25 Priorities of Recruitment in Manufacturing Industries by Fields of Work



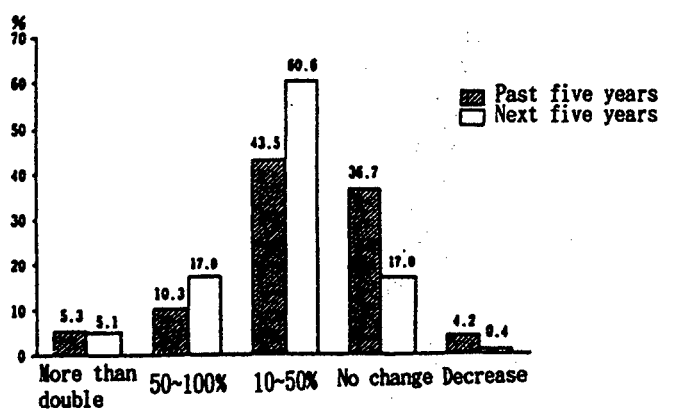
A: Production Plants
B: Sales/Marketing
C: Business planning
D: Financial management
E: Information system management
F: R&D
G: Other
H: No change
Note: Multiple responses (from the survey by the Economic Planning Agency)

(2) Present status and future outlook of securing a supply of researchers and engineers

In the last few years, the most important aspect of acquiring human resources in industry has been employing as many researchers and engineers as it needed. Japan is now in its fourth year of the most recent business boom, which has brought with it severe difficulties in recruting personnel, specifically researchers and engineers. As a result, about 80% of all companies surveyed report difficulty in obtaining researchers and engineers, primarily science and engineering graduates.

There continues to be a high demand for researchers in industry, and in general many Japanese companies are still eager to increase the size of their staff for the next 5 years. About 61% of them expect to expand between 10% and 50% in the next 5 years, and 22% of them plan to expand their staff by at least 50% in the same period.

Chart 27 Rate of Increase/decrease in Number of Corporate Researchers



(3) Increasing mobility and diversification of human resources

The increasing sophistication, complexity of research and development and the reinforcement of research functions, have been accompanied by a need for greater mobility of human resources. Even in industry, restructuring and changes in

product demand structure have resulted in a somewhat large scale search for external human resources to provide companies with experienced staff. About 74% of Japanese companies, primarily high-tech firms, are either currently considering, or have begun to formally employ experienced workers from outside the company.

With the number of new graduates levelling off as a result of changes in population structure, the aging of the population for example, and a fall in the school age population, a long-term shortage of researchers and engineers is forecast, creating the need for the diversification of human resources. As a result it is expected that superior researchers will continue to serve even after they reach normal job rotation age, and that more women will be recruited in the research and development divisions. In addition, there has been an increase in the employment of foreign researchers.

5. Enhancing the scientific and technological potential of the local regions

(1) Scientific and technological capability of the regions

The distribution of researchers is the most important factor in determining the scientific and technological potential of a region and there is a particularly strong demand for human resources in all regions. According to the corporate survey made by STA, 49% of all researchers in industry are concentrated in the Tokyo area (Tokyo, Kanagawa, and Saitama). However, many researchers in industry work on development projects usually undertaken near manufacturing plants, and a few are scattered about in areas where their employers have established manufacturing facilities.

Science & engineering faculty members of Japanese universities are evenly distributed throughout the country because national and other public universities are located in many parts of Japan.

National research institutes employ about 10,000 researchers. Along with approximately 4,500 working at Tsukuba Science City in Ibaraki Prefecture, 2,800 work Tokyo, and about 600 work in the Osaka area.

Research facilities operated by private companies also tend to be concentrated in the Kanto (including Tokyo) region, and generally the interdependency does not necessarily exist between these research centers and the areas where their

Chart 28 Number of Corporate Researchers by Region

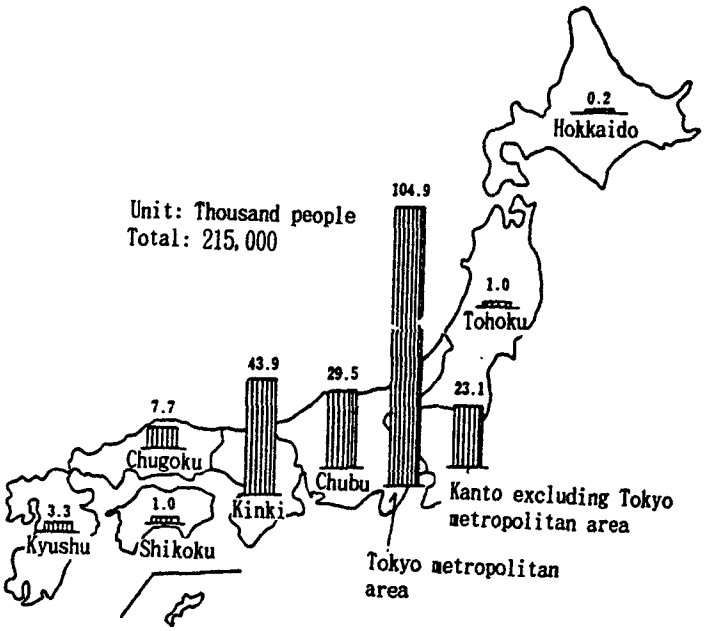
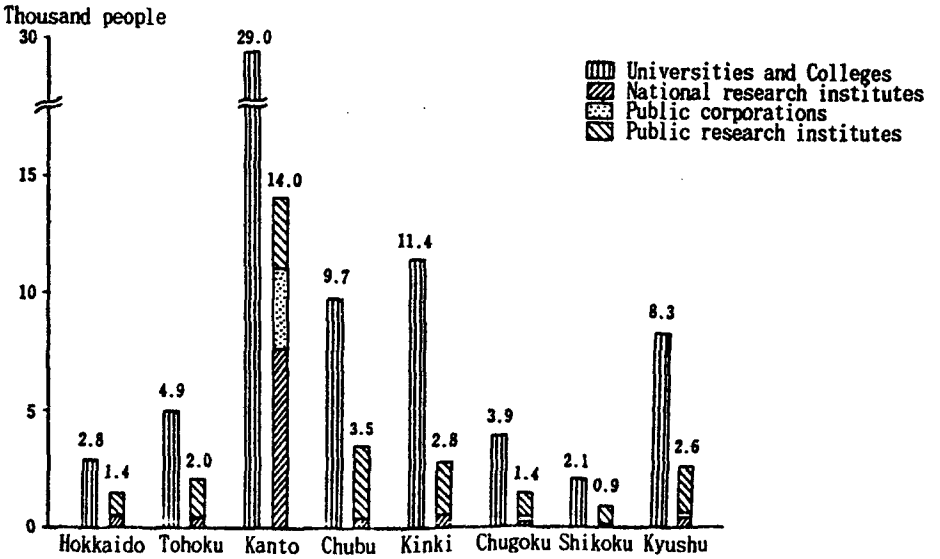


Chart 29 Natural Sciences and Engineering Full-time teachers in Universities and Colleges, and Regular Researchers in Research Institutes by Region



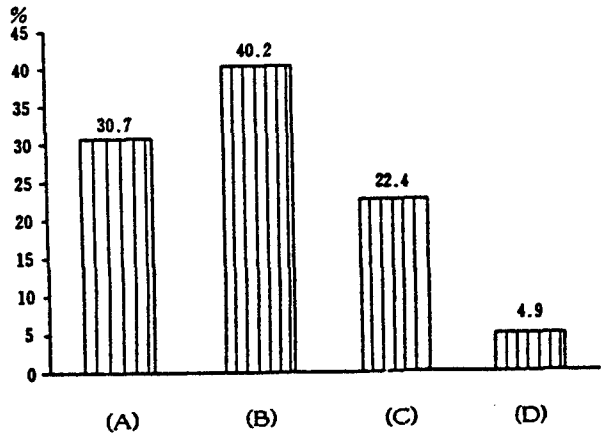
companys' factories are located. But in recent years more high-technology industries have been locating more factories in the local regions, and this is expected to enhance the scientific and technological potential of these regions.

(2) Furthering science and technology policies in the regions, and stimulating local activity

Many local governments in Japan consider science and technology one of a major driving forces in regional development, and are taking positive steps to promote it. These include the decision of science and technology promotion guidelines (18 prefectures), and the establishment of commissions responsible for science and technology (11). In many cases, local government have adopted policies such as reorganization of public research institutes (26), or the public and private sectors jointly establishing an organization to conduct or assist research and development projects. It may be possible for such regional science and technology promotion activities to fill a certain role in characteristic fields as in biotechnology, ceramics research, etc.

Locally oriented research activities conducted by national research institutes scattered through all regions, relationships between the national universities and the regions maintained through joint research centers (already set up in 13 universities), and research and development programs carried on by local,public testing and research organizations in close cooperation with the regions, are all expected to contribute to the enhancement of the science and technology capability of the regions in the future.

Chart 30 Researchers' Views to the Local Government's Policies for Promotion of Science and Technology



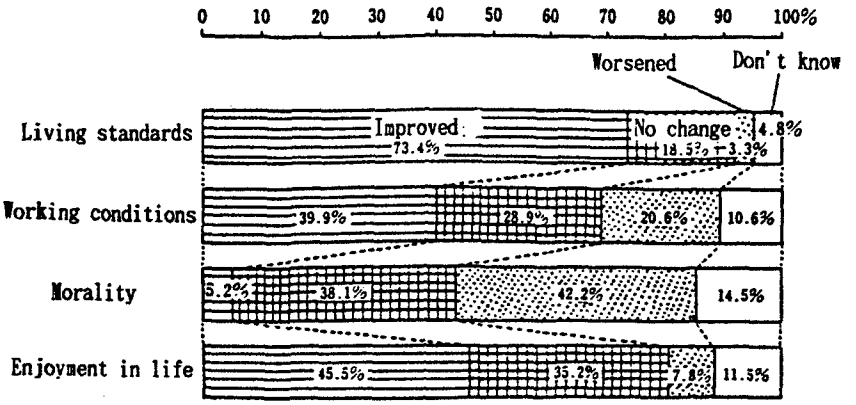
A: Enrichment and diversification of Japanese R&D activities
B: A part of role to promote R&D activities
C: Not find the role at present
D: Not expect so much

6. New demands upon science and technology

(1) Improvement in the quality of life and people's real richness

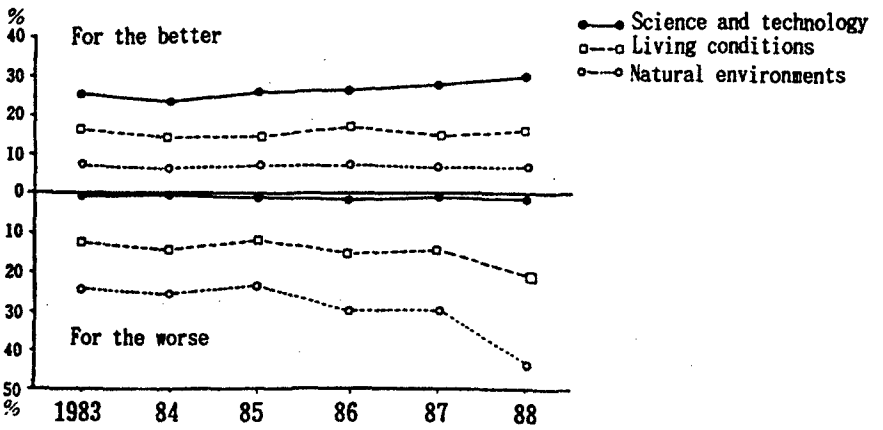
Up till the present time, science and technology have primarily been used to create material wealth as a means to increase convenience and comfort, and have made great contributions to the improvement of our standard of living and working conditions, and to making people's lives more enjoyable. But recently, new issues have come to the fore:

Chart 31 Has Scientific and Technological Progress Improved the Quarity of Life?



Source: Prime Minister's Office "Public Opinion Poll on Science and Technology and Society" (March, 1987)

Chart 32 Is Japan Going to Be a Better Country?



Source: Prime Minister's Office "Public Opinion Poll on Social Awareness" (1983-1988)

responding to the diversified needs including spiritual richness of individuals and of society, and increasing the quality of our lives even more.

Consequently, we must continuously work to apply science and technology to the search for solutions to a broad range of social problems, devise ways to harmonize science and technology with society and the life of the people, and seek to create not only material but spiritual richness in various areas.

(2) Ethical issues in science and technology

Society has had difficulty harmonizing with and accepting rapid scientific and technological progress. The progress of life sciences has brought ethics of life (bio-ethics) into question. This has raised social issues such as brain death, organ transplantation, terminal care and life support. Serious issues which call for a solution by society as a whole include the protection of privacy and the pursuit of spiritual richness which are problems raised by the emergence of information society and the introduction of large scale automation and robotics to raise productivity have forced us to deal with the relocation of human resources. It is necessary for both the natural sciences, and the humanities and social sciences to become involved in an integrated research to discover the desirable relationship between science and technology on one hand, and man and society on the other.

The life sciences are comprised of relatively new areas of research focused on humanity, and to that extent, it will be necessary to carry out a broadly based and probing examination of life science research, its results, and utilizations. By broadly based, it is meant that not only the natural sciences, but philosophical, legal, ethical, and religious approaches must be involved on this issue. An discussion focused on ethics of life scienses is already in progress from varied viewpoints presented at the Council for Science and Technology.

The more search for a way to harmonize science and technology with humanity and society must continue. Furthermore, in every field and every project concerned, activities should be implemented and evaluated based upon a full awareness of the social and ethical aspects of science and technology.

(3) Global environmental issues and science and technology

Global environmental problems such as the destruction of the ozone layer, global warming, desertification, acid rain should be most urgently solved through fully utilizaing science and technology from now on. These include technological development required to provide observation and

surveillance abilities, clarify the nature of phenomena and their effects, and create counter measures to solve these problems.

Global environmental problems are serious issues which deeply effect the foundations of the existence of human life. Throughout the world, the concept of "sustainable development" has become common recognition whose idea means that development should be made without destructing the environment which is the base for future progress. The basic route to preserve the environment is to emphasize the importance of scientific knowledge and to take positive action to solve these problems using technology as well. What is required of science and technology is the development and dissemination of related technology accompanied by positive contributions to international activities aimed at global environment protection and strenuous efforts to solve environmental problems.

Under these circumstances, while conducting its high level economic activities and remaining deeply involved in the global environment, Japan, with its superior technological power, must fulfill a role appropriate to its international status, taking into account its national initiative "Japan which contributes to the international community".

In Japan, the basic direction of national policy in regard to science and technology is shown in the actions of the Cabinet meeting concerned with the protection of the global environment, and in the report of the Global Science and Technology Subcommittee under the Council for Science and Technology. Industry is making energetic development of emmission control technology and alternative materials needed. The nation as a whole is expected to act together to devise positive countermeasures.

Chapter 2. Changes in International Environment in Science and Technology, and Japan's Response

1. Continued globalization of technology

(1) International dissemination and penetration of technology

(Factors for the globalization of technology)

Technology is becoming increasingly globalized as the various conditions necessary to accelerate its transfer and to permit it to disseminate and penetrate now exist. These include the spread of transnational business activities which accompany international transfer of technology, the initiation of aggressive research and development in many nations as a means of national development, and the proliferation of advanced technology utilization. It could be said that an international environment has appeared where science and technology is one of the major axes in relation among nations.

Consequently, trade in technology continues to grow, particularly among the advanced nations, the United States being the overwhelming giant in technology trade. The trade in high-technology products is also growing rapidly, and now accounts for about 10% of the world's trade total.

Chart 33 U.S. Receipts and Payments of Royalities and license fees by Country/Region

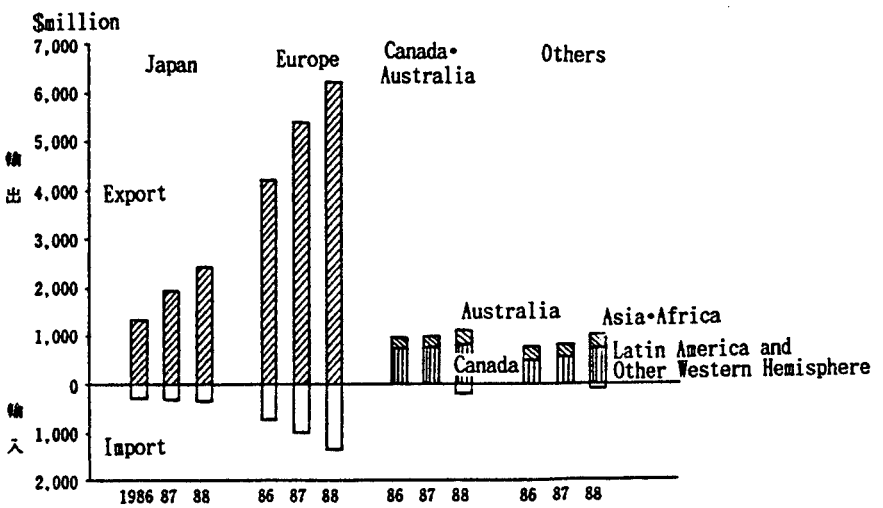
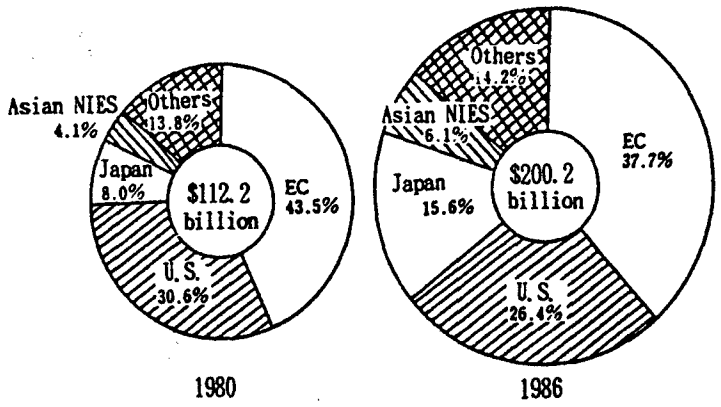


Chart 34 Expansion of High-Tech Exports by Share



Another factor encouraging the international flow of technology is the change in the relationship between the advanced countries and the developing countries from a vertical division of labor to a horizontal division fo labor.

(Japan's response in the offshore location of research and development facilities, and in the expansion of researcher exchanges)

Another factor which is increasing the globalization, dissemination, and penetration of technology is manufacturing industry's activity accompanied by the international expansion of research and development. The siting overseas of research functions is entering a new stage in Japan.

Japanese companies have opened research and development facilities at 188 overseas locations, employing 4,378 research personnel. About 30% of Japanese companies surveyed with capital of more than 10 billion yen, have already located, or are planning to locate, some form of research and development function overseas. The scale and nature of these facilities vary widely. In many cases, they report that it was established to serve the needs of the local market, or as part of a program to multinationalize their company's business activities. About half of companies have made no decision concerning an overseas location yet. It can be said that many firms, confident in the strength of domestic research and development, and wishing to secure that their research and development capability is integrated with Japan's superior production technology, have taken a cautious attitude towards the issue.

Chart 35 Corporations' Policies for Activities in Overseas R&D Bases

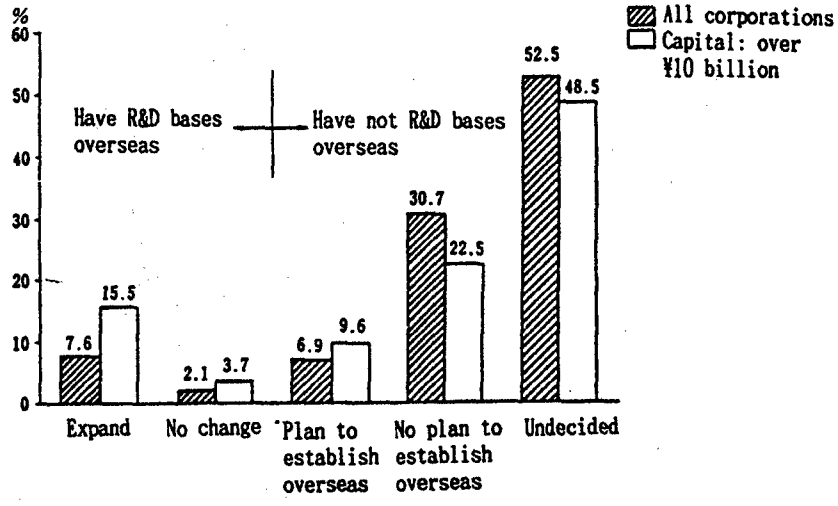
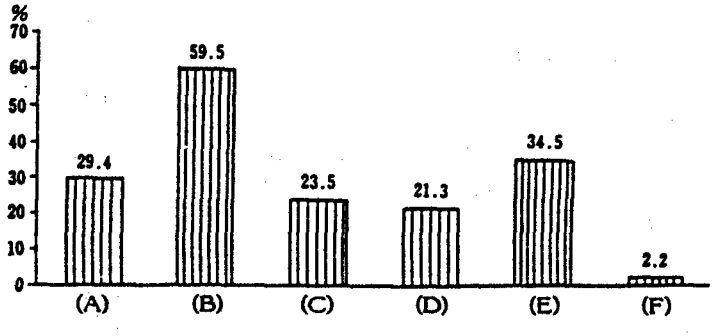


Chart 36 Reasons to Establish Overseas R&D Institutes by Corporations



A: Strengthen production plants' technological capabilities
B: Satisfy needs of the local market
C: Research exchange/personnel development through joint research with major universities and research institutes
D: Secure research personnel in an effort to activate and rationalize R&D
E: Out of necessity to promote globalization of corporate activities
F: Other
Note: Multiple responses

However, it is likely that as manufacturing firms increase offshore production in the future, more research functions will be established overseas, primarily to satisfy the needs of the local market, and for companies to make a contribution to the local community.

Notable, but oppsite move is that more and more foreign affiliated companies set up research centers in Japan. The number of such research institutes in manufacturing industry reached 100 in 1986.

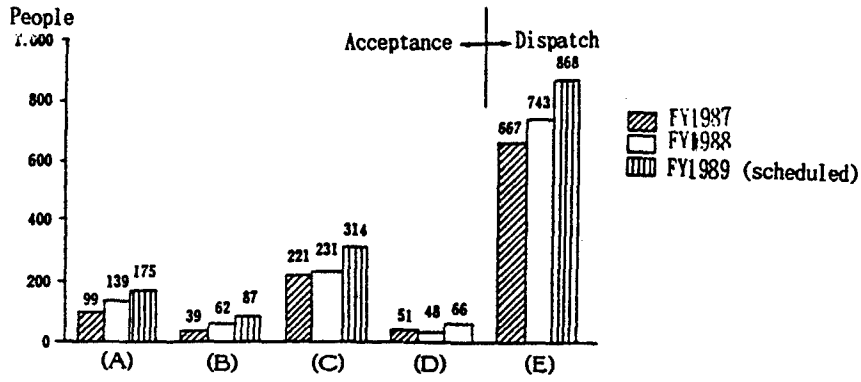
Table 2 Number of Research Institutes Established by Foreign Companies (Manufacturing)

Year	-1971	1972-1974	1975-1977	1978-1980	1981-1983	1984-1986	Total
Number of research facilities	46	9	7	11	8	21	102

Source: Ministry of International Trade and Industry "The 20th/21st Survey on Foreign-based Companies"

There has also been a steady increase in international exchanges of researchers by industry, government and the academic community. Industry is accepting or employing a number of researchers, and the balance is being achieved in terms of the number of researchers exchanged.

Chart 37 International Researchers Exchange by Japanese Corporations



A: Employment/hiring (regular staff)
B: Invitation/fellowship (non-regular staff)
C: Training
D: Acceptance through mutual exchange
E: Dispatch of researchers
Source: Science and Technology Agency "Survey on Research Activities by private Enterprises" (1989)

(2) Increasing international exchange of science and technology and the intensification of technology competition

The internationally recognized basis of scientific and technological development has always been the freedom of researchers to associate with one another and to perform research and development, and the free flow of the results of their work. It is now more important than ever before to contribute to the world wide development of science and technology by promoting the international movement of researchers and the smooth distribution of information about the results of their research, and at the same time, to encourage harmonious international research cooperation. This is because research and development is conducted on a larger scale, and there are more global projects in nature which deal with issues such as the global environment, and these research and development requires a comprehensive approach based on cooperative relationships between various scientific fields and different countries. International cost sharing has also become normal measures.

But on the other hand, as the role of economic strength increases in international power relationships, all countries are aggressively striving to reinforce the source of their economic power, namely, competitive and technological strength. On one hand, this promotes international technological competition and is the motive power behind economic and social development, but on the other hand it generates friction. Therefore, appropriate, harmonized measures must be taken to deal with this problem by both advanced and developing countries.

(3) The promotion of international competition and cooperation

There is a great concern for an increase in international tension in the technology area as each nation, developed or developing, enhances their technological capabilities. But sound tension between these countries promotes competition and benefits them all. It is necessary to create an environment which maintains and expands smooth competitive relationships.

But today it has become increasingly necessary for regions and nations to cooperate, beginning with environmental problems. Both developed and developing countries can cooperate in many ways from industrial technology cooperation to technical assistance to basic research. But generally speaking, when competition is stressed excessively, there is a danger of interfering with cooperative trends. Japanese science and technology has advanced to a level which enables it to make a positive contribution to balanced cooperation and competition.

Today we are seeing the signs of techno-nationalism or regionalism, a tendency for nations to attempt to monopolize technology. In the midst of this trend, it is necessary for Japan to be fully aware that healthy competition and smooth cooperation are the key to the development of science and technology throughout the world, and to strive to promote or encourage such competition and cooperation in the international community. It is hoped that other countries will also work to achieve this goal.

2. Science and technology in other nations

(1) Imbalance in technological capability and strengthening of competitiveness in the United States

In the U.S., the wide range of multinational business activity, the dependence upon foreign sources for many manufactured products, and the corporate posture stressing short term profits and theory of management supremacy have resulted in a comparative decline in domestic production technology and scientific and technological capability. Recently the rate of increase in research and development investment by both private industry and government has tended to fall. But the U.S. industry is now doing a great deal to try to increase its international competitiveness. These activities have been brought together in comprehensive form with the legislation last year of the "1988 Omnibus Trade and Competitiveness Act," which provides legal backing for the strengthening of the nation's competitiveness. But the law is considered not necessarily sufficient for the competitive purpose by members of the U.S. Congress and industry, where there are moves in support of more concrete measures. The exchange rate adjustment which followed the G5 Plaza agreement and efforts by the U.S. to strengthen its competitiveness have resulted in signs that trade in the U.S. high-technology products is improving. The United States showed a deficit in high-tech trade for the first time in 1986, but since then it recorded a surplus for the last two years.

While the United States has, in this way, generally lost strong ground in science and technology seen in the past, it is maintaining its strength in basic research. The United States is working to maintain and increase its strength by expanding investment in basic research --- the base of long term progress --- more than it is expanding investment on

Chart 38 U.S. Trade Balance in High-Tech Manufactured Products

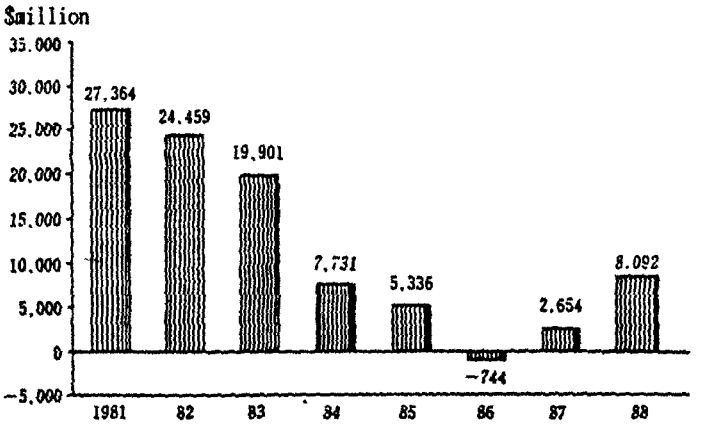
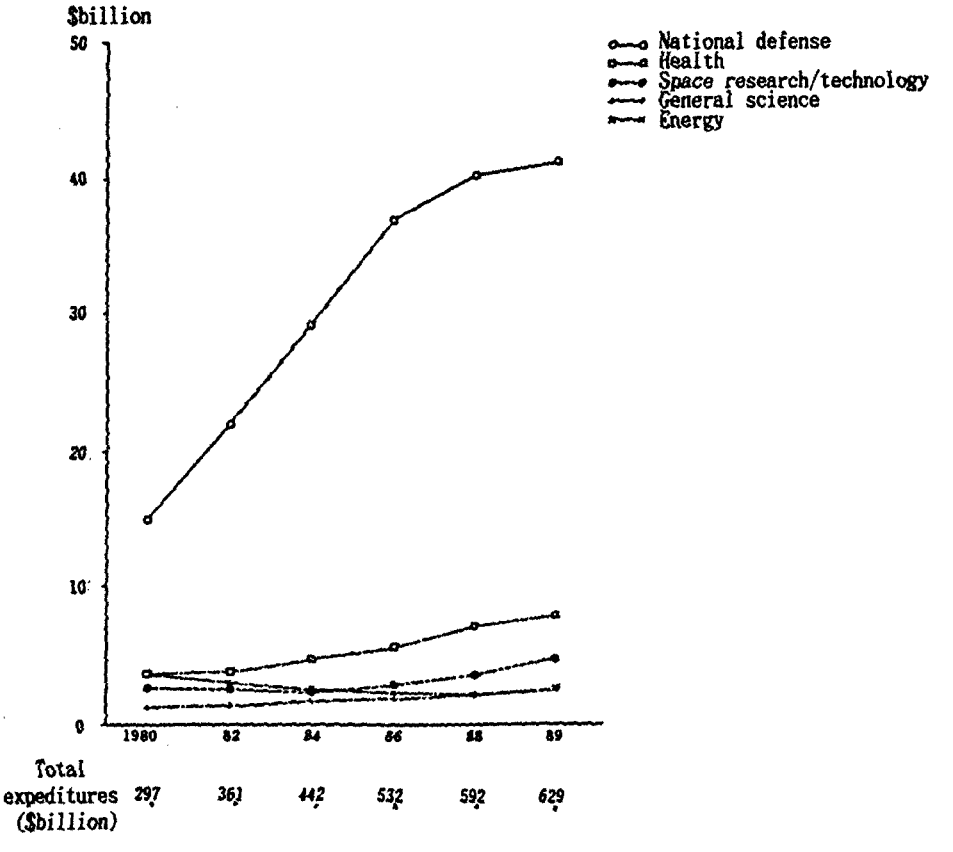


Chart 39 Trends in the U.S. Federal R&D Expenditures (by budget function)



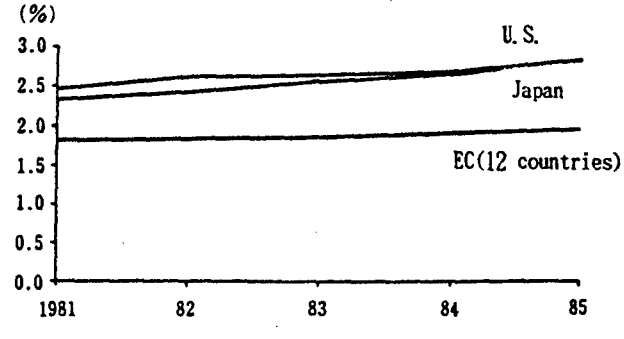
development intended to bring technological benefits.

During the 1980s the U.S. government expanded investment in research and development to strengthen its national power, but this investment was heavily weighted towards defence research. The Bush administration also stresses the enhancement of science and technology, and the new budget which the congress enacted provides for sharp increases in civilian research such as space and scientific research. But it is not clear whether these steps will successfully lead to the strengthening of U.S. competitiveness and the restoration of overall scientific and technological capability. It is necessary to carefully observe the future position of the Bush administration and the congress, and the actions of U.S. industry.

(2) Europe strengthening its technological capability toward the EC market unity

In the midst of major international trends of, an acceleration in the tempo of the technological innovation and greater use of advanced technology in industry, the European countries have become acutely recognized the necessity of balanced scientific and technological development. At the each national level in particular, there has been insufficient research and development investment in industry. As a result Europe has fallen behind the United States and Japan in high-technology. In recent years, a major issue in Europe has been to establish the competitive position with the U.S. and Japan in high-technology areas. The First Report on the State of Science and Technology in Europe prepared by the EC commission calls for efforts to develop broadly-based scientific and technological capability to respond to the needs of international competitiveness and to social needs by improving the quality of life, and also to acquire solid basic research strength, on the premise that the European market would be unified in 1992. To achieve

Chart 40 Trends in Ratio of R&D Expenditures to GDP



Source: EC commission

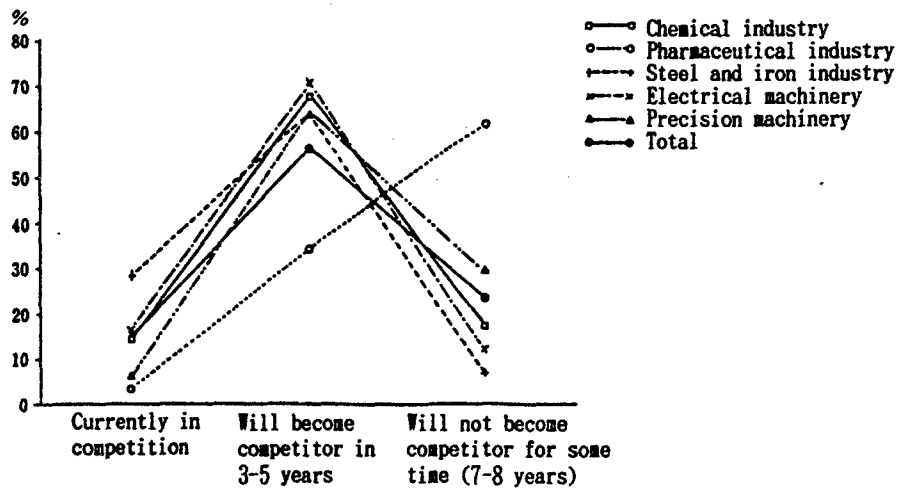
these objectives West Germany, France and other EC countries are working to strengthen science and technology. But it has become difficult for one country acting alone to achieve enough results and succeed in strengthening industry.

The role of the EC is to supplement the efforts of the individual country and to show the policy goal for EC countries as a whole. At the same time it is promoting transnational cooperation through the Framework Program The Eureka is also successfully managed among multinational cooperation. With the EC single market drawing near, it is necessary to carefully observe these progresses.

(3) Rising technological abilities in Asean countries

After experiencing a temporary slowdown in economic growth in the mid 1980s, the NIEs and ASEAN countries are achieving rapid growth through industrialization based upon continuing enhancement of their technological background. In these countries where it is believed that the foundation of national development is the acquisition of science and technology ability and the human resources which surpport it, the promotion of science and technology is the chief element in national planning, the creation of human resources is stressed, and administrative systems are established to promote science and technology programs. The Asian NIEs, Korea in particular, are catching up technologically, and have become major exporters, even in high-technology manufactures trade. As a result of active promoion of technology in the NIEs, seventy percent of Japanese companies view that Asian NIEs will become technological competitors of Japan within 3 to 5 years. Consequently, it is considered quite likely that if Japan does not achieve sufficient technological progress, the NIEs will catch up with it in the near future.

Chart 41 Comparison of Technological Capabilities between Japan and Asian NIES



Chapter 3. Future issues and prospects

1. Nowadays, it is necessary for Japan to find its own science and technology course, lay the foundations for long term development at home, and at the same time, fulfill its important international role as a major growth center for science and technology. In the past, Japan has attempted to respond positively to a changing economic environment using science and technology as a main tool, and has successfully overcome the challenges posed by that change. In order to maintain this vitality, we expect that industry will continue to play a major role, and that through its own efforts and dynamism steady progress will be made in dealing with issues such as the promotion of applied or development research directly related to industry and the maintenance of the strong technological base which supports the manufacturing sector. On the other hand, it will be necessary for the public sector to nurture the future scientific and technological potential required to deal with fundamental changes in the economic and social environment.

2. In recent years, science and technology activities in the private sector have made remarkable turnaround, particularly in quantitative terms, but this does not necessarily mean that the functions of the public sector are all taken care of. If Japan's international position is taken into consideration, the public sector will continue to play an active role. The government will stimulate the dynamic scientific and technological activities of the private sector, and expect industry's own efforts. On the other hand, it is necessary that the public sector trys to increase R&D investment to the level on a par with those of the U.S. and Europe (for example, 1% of GNP), and at the same time, plan a suitable response paying special attention to the following points.

(1) For a full scale build-up of basic research, improve the research capabilities of universities and public research institutions and simultaneously, increase funding on basic research.

(2) Many of Japan's internationalization policies have barely begun, so based on the concept of globalism of science and technology, actively promote the internationalization of its science and technology.

(3) Make an aggressive effort to harmonize science and technology with people and society, and in particular, use it to deal with global environmental problems.

(4) Work to nurture and develop the scientific and technological potential of the local regions of the nation.

(5) Carefully examining the changing consciousness or view of science and engineering students toward manufacturing industry, work to guarantee a sufficient supply of superior science and engineering talent.

3. Conclusion

Today we are in the midst of dramatic social and economic structure changes in Japan. We can probably position science and technology as the locomotive which will allow us to respond flexibly to these changes, and enable to accomplish real richness of life which its people now aspire.

As a major world leader in science and technology, Japan should now play an honorable role appropriate to its national power.

In this way , as it enters the new Heisei era, Japan is expected to make greater efforts than ever before to achieve superior science and technology which will enable it to make needed contributions in many fields, both in Japan and abroad.

Part 2. Trends in Scientific and Technological Research Activities

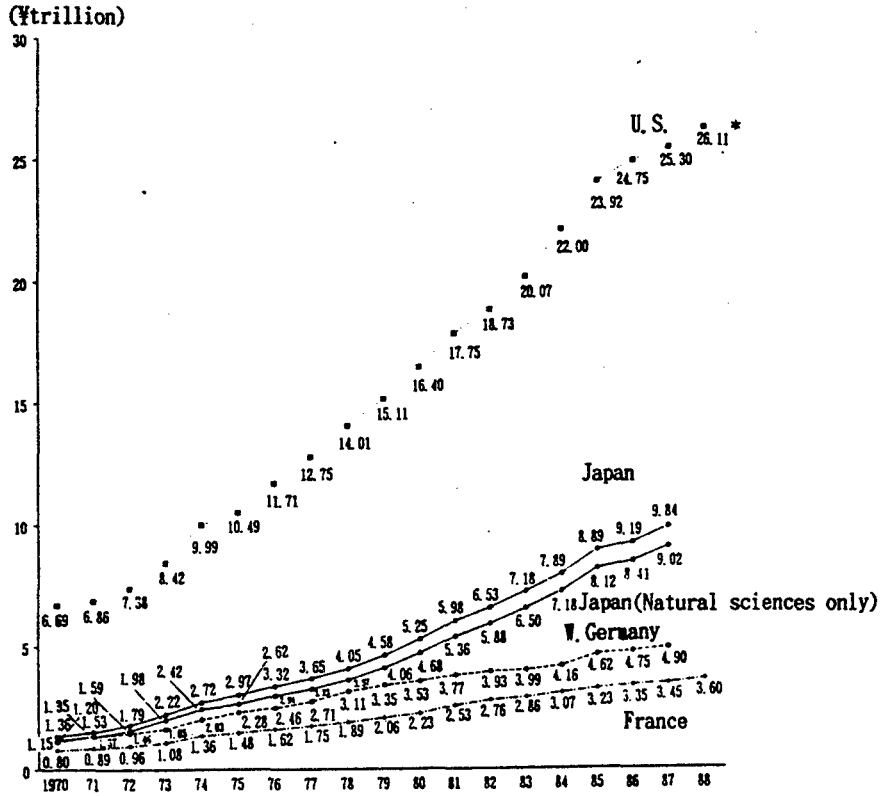
1. Research expenditures

In fiscal 1987, Japan's research expenditures reached a total of about ¥9.2 trillion, a 6.5 percent up (in real terms) to the previous year, ranking second, just behind the United States.

A glance at research spending (actual amount used) by organization shows that private enterprises accounted for a large proportion of overall spending in fiscal 1987, about 72 percent.

The Government bears about 20 percent of Japan's research expenditures, while the private sector bears a 80 percent. This reflects the brisk R&D investment in Japan's industrial sectors.

Chart 42 Trends in R&D Expenditures in Major Countries



Note: The amount converted to the Japanese yen based on the OECD's purchashing power parity.

Chart 43 Increase in R&D Expenditures in Major Countries (in real terms)

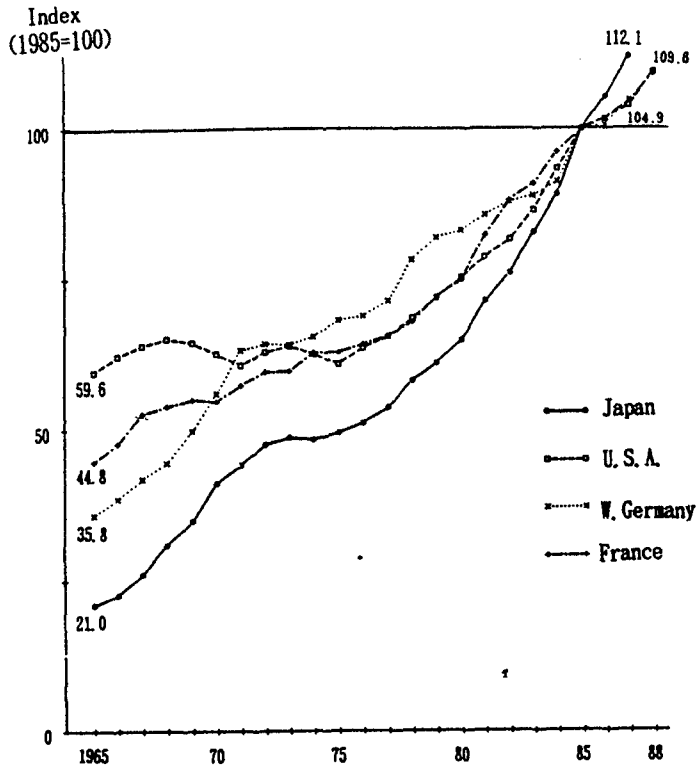


Chart 44 Trends in Ratio of R&D Expenditures to GNP in Major Countries

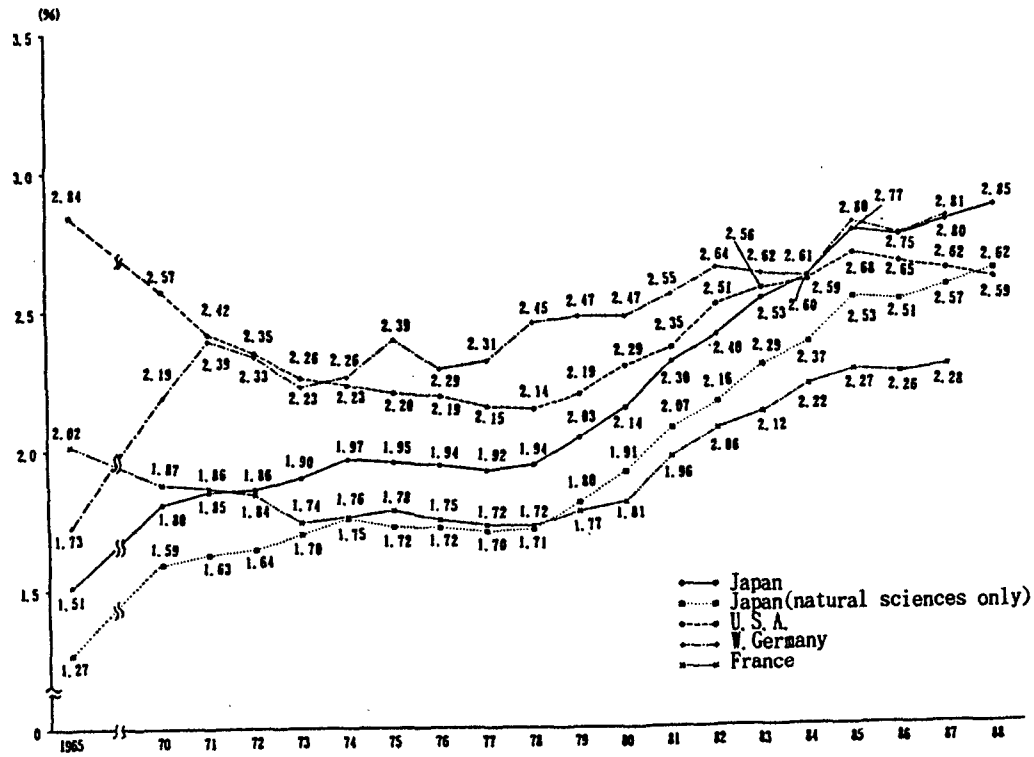


Chart 45 Trends in R&D Expenditures by Sector

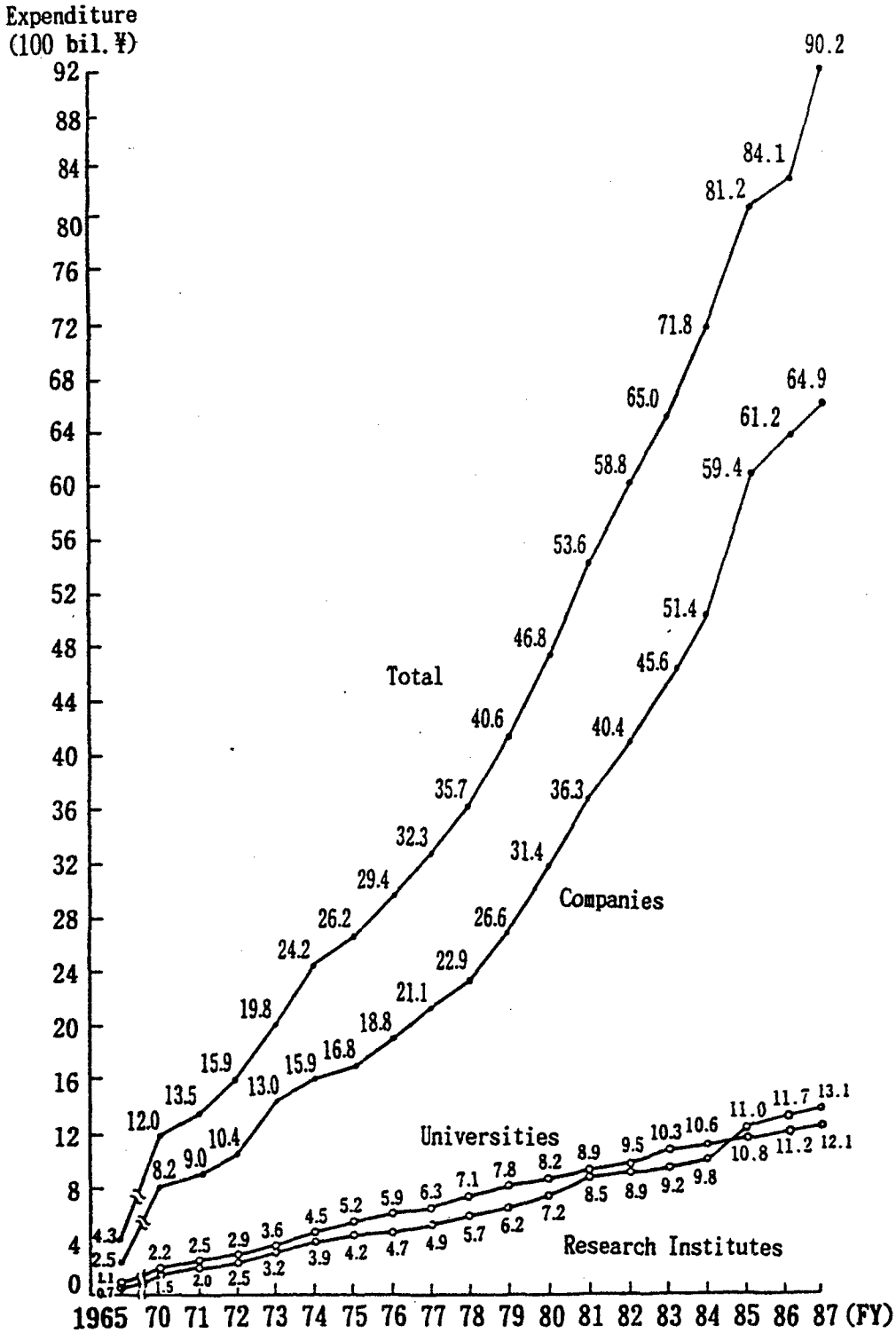
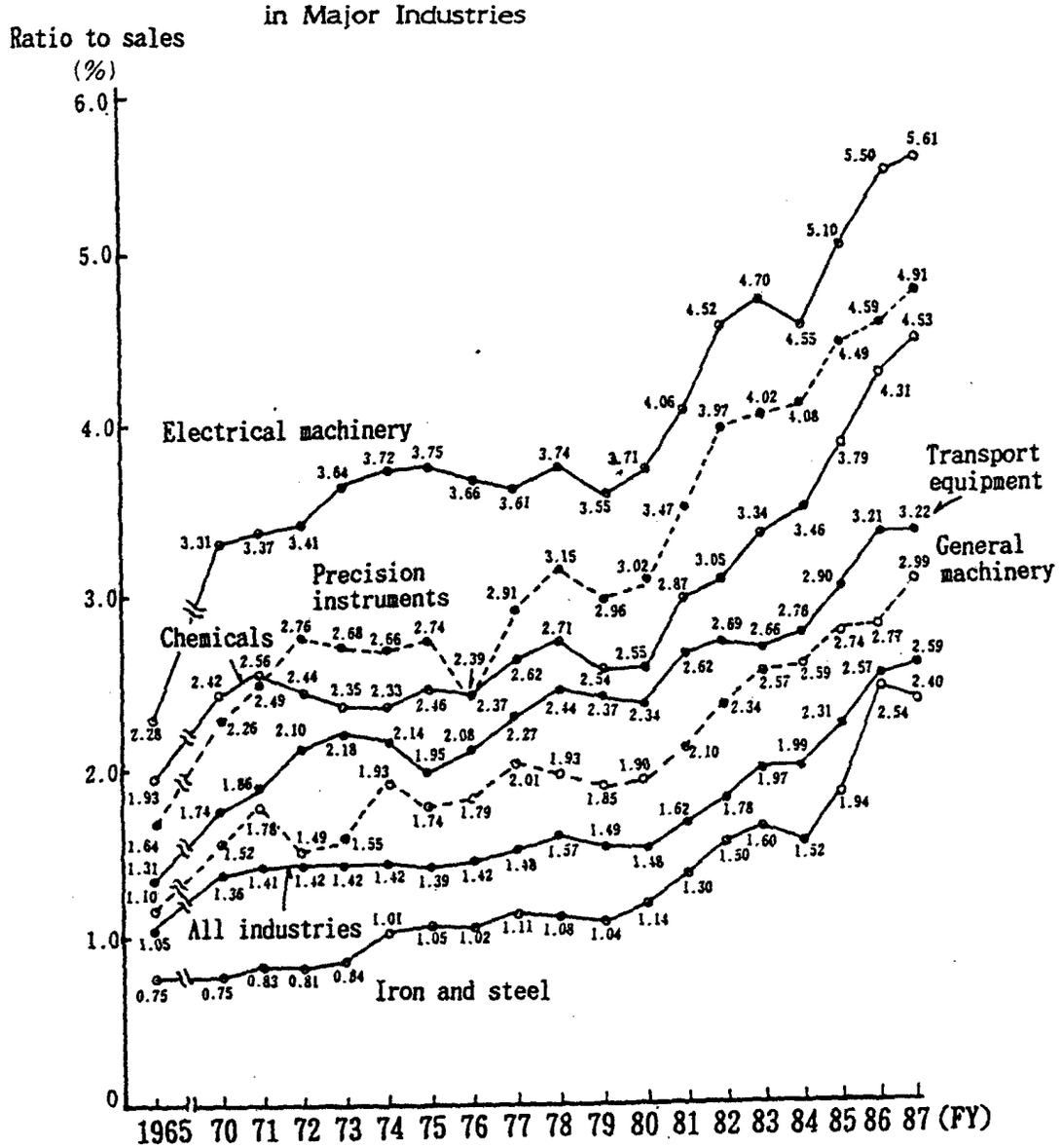


Chart 46 Trends in Ratio of R&D Expenditures to Net Sales in Major Industries



2. Researchers

In 1988, Japan had a total of 442,000 researchers (natural sciences only). Viewing this in terms of organization, one can see that 63.2 percent were working in private enterprises, 29.0 percent in universities, and 7.8 percent in research institutes. When compared with other industrial nations of the West, Japan has just about the same the number of researchers for every 10,000 people as does the United States.

Chart 47 Trends in Number of Researchers

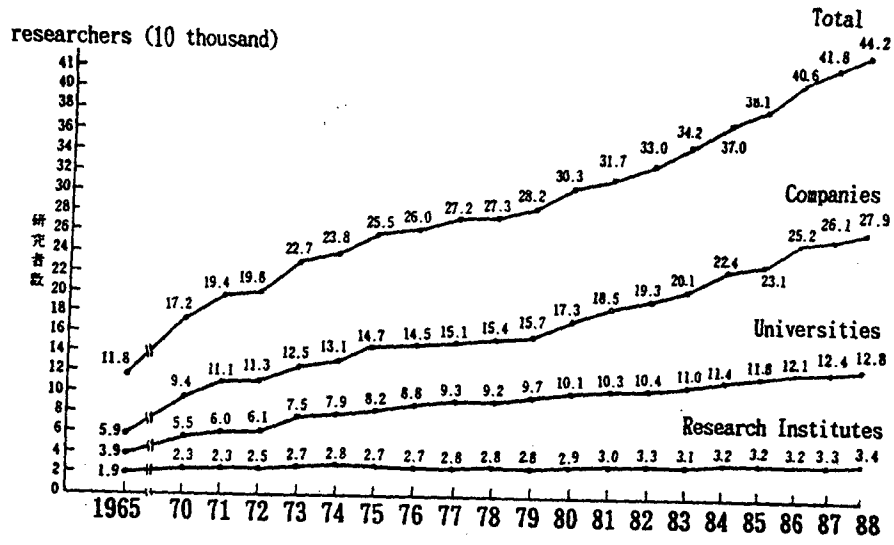
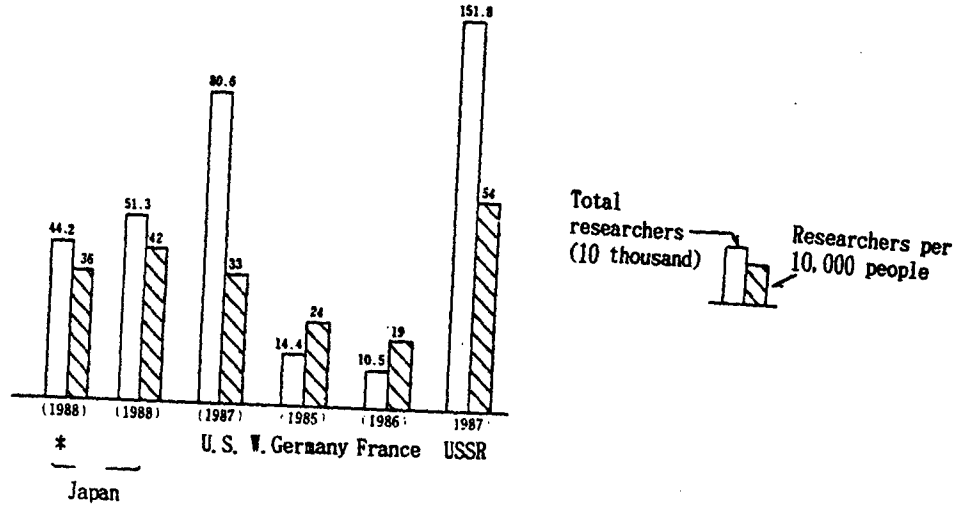


Chart 48 Number of Researchers in Major Countries



* natural science only

3. Technological trade

Although Japan's technological trade balance on a new contract basis within one year had continued to show more technology being exported than imported since fiscal 1972, in 1987 it recorded a deficit. In terms of overall trade balance Japan continues to import more than it exports. In 1988, Japan exported technology worth a total of ¥210 billion, while it imported a total of ¥643 billion worth of imports.

Chart 49 Regional Trade Balance of Japan (FY 1987)

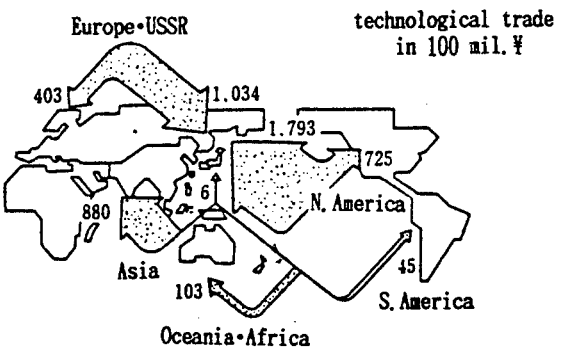
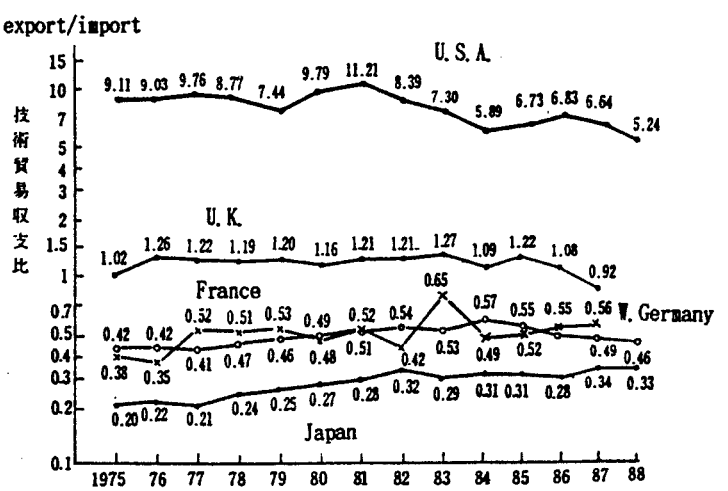


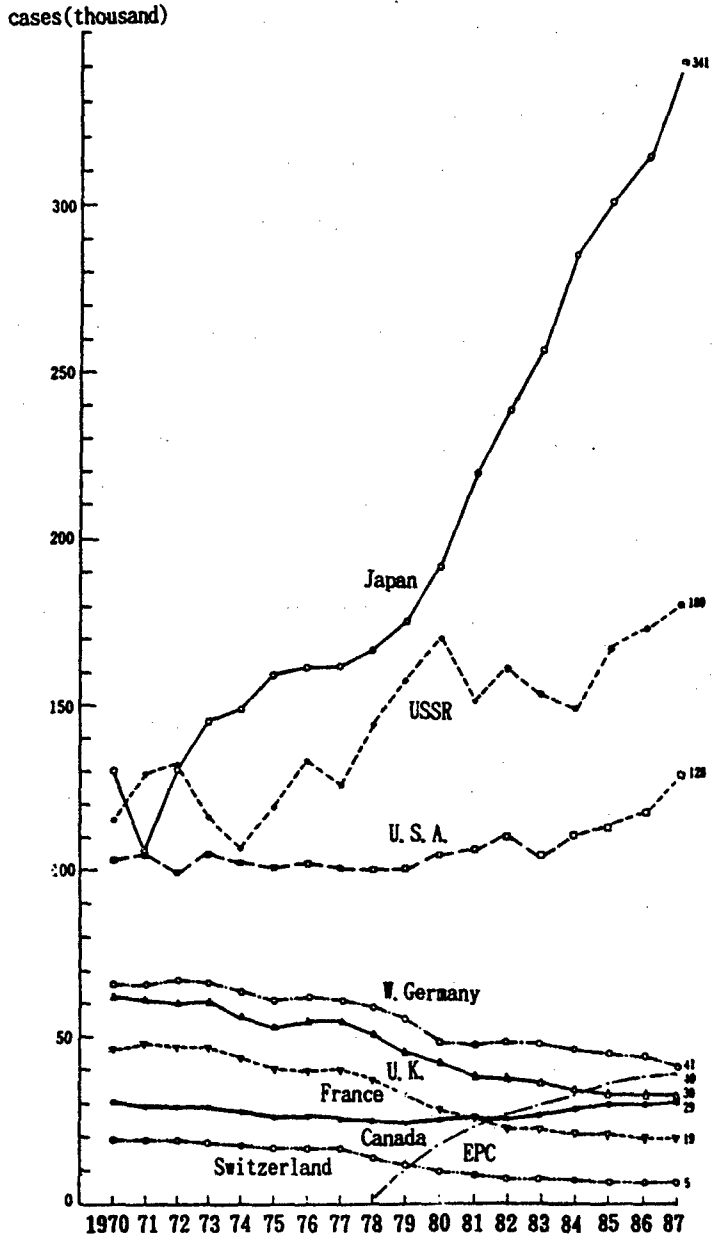
Chart 50 Trends in Technological Balance of Payments in Major Countries



4. Patent application

Reflecting the rise in the levels of its technology and its vigorous R&D drive, patent applications in Japan continued to increase in number until 1987. But in 1988 the number decreased by 0.5%. Japan now registers the highest number of patent applications in the world.

Chart 51 Trends in Number of Patent Applications in Major Countries



Part 3. Government Policies

1. Japan's science and technology policies

Based on the guidelines prepared by the Council for Science and Technology, Japan's highest deliberating body for science and technology policies, the Government adopted at its (March 1986) Cabinet meeting a report entitled "General Guideline for Science and Technology Policy." This report which shows the Government's basic stance on S&T is comprised of the following three basic principles:

(1) Promoting highly creative science and technology centered on reinforcing basic research;

(2) Harmonizing science and technology with man and society.

(3) Developing science and technology with due attention to global aspect;

2. Recent activities of the Council for Science and Technology

(1) Inquiry No.12 Report in response to "General Guidelin for Science and Technology Policy" (December 1985)

(2) Inquiry No.13 Report in response to "Guideline for National Research Institutes over the mid-and long-term" (August 1987)

(3) Inquiry No.14 Report in response to "Basic R&D Plan for Science and Technology Related to Matter/Materials" (August 1987)

(4) "Summary of International Issues Regarding Science and Technology" (September 1988)

(5) Inquiry No.15 "Basic R&D Plan for Science and Technology Related to Information and Electronic"

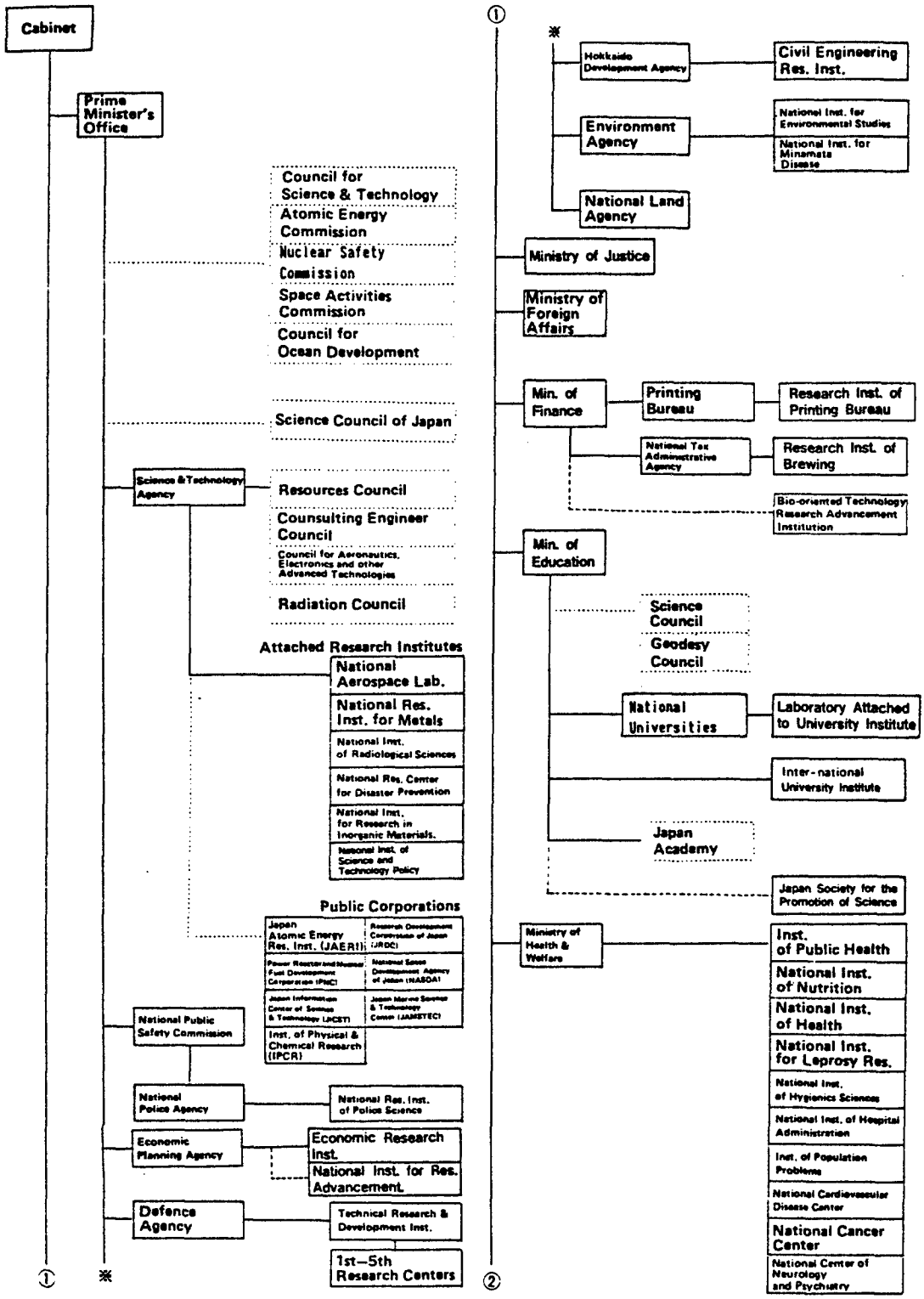
(Currently under deliberation)

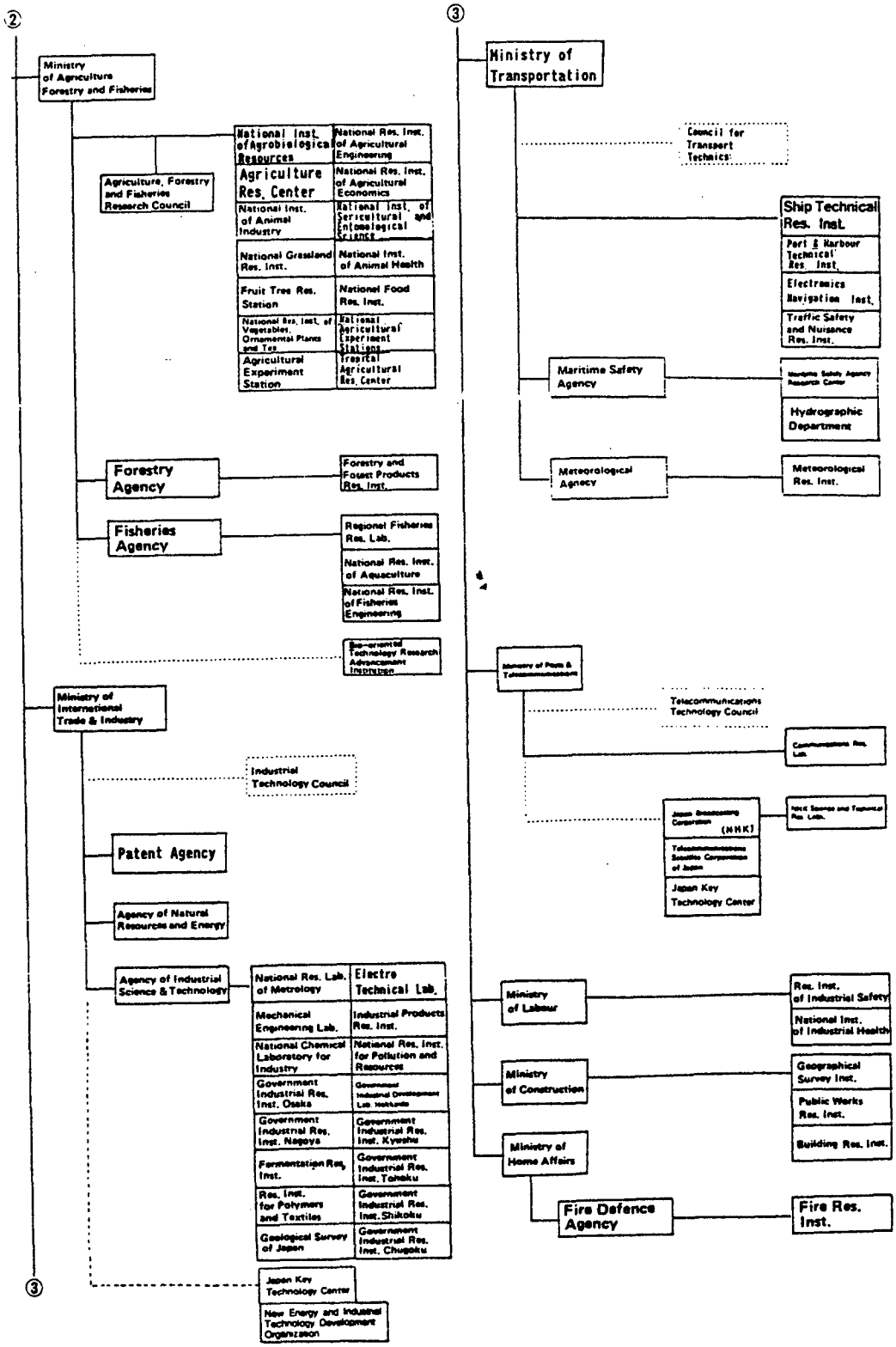
(1) Inquiry No.16 "Basic Plan for Laying the Foundation for Promoting Science and Technology"

(2) Inquiry No.17 "Basic Plan for Science and Technology Related to the Earth"

(3) Report of Ad-hoc Committee on International Affairs, the S&T Council

Chart 52 Administrative Structure of Science and Technology




②
Ministry of Agriculture Forestry and Fisheries
National Inst. of Agrobiological Resources
National Res. Inst. of Agricultural Engineering
Agriculture Res. Center
National Res. Inst. of Agricultural Economics
National Inst. of Animal Industry
National Inst. of Sericultural and Entomological Science
National Grassland Res. Inst.
National Inst. of Animal Health
Fruit Tree Res. Station
National Food Res. Inst.
National Res. Inst. of Vegetables, Ornamental Plants and Tea
National Agricultural Experiment Stations
Agricultural Experiment Station
Tropical Agricultural Res. Center
Agriculture, Forestry and Fisheries Research Council
Forestry Agency
Forestry and Forest Products Res. Inst.
Fisheries Agency
Regional Fisheries Res. Lab.
National Res. Inst. of Aquaculture
National Res. Inst. of Fisheries Engineering
Bio-oriented Technology Research Advancement Institution
Ministry of International Trade & Industry
Industrial Technology Council
Patent Agency
Agency of Natural Resources and Energy
Agency of Industrial Science & Technology
National Res. Lab. of Metrology
Electro Technical Lab.
Mechanical Engineering Lab.
Industrial Products Res. Inst.
National Chemical Laboratory for Industry
National Res. Inst. for Pollution and Resources
Government Industrial Res. Inst. Osaka
Government Industrial Development Lab. Hokkaido
Government Industrial Res. Inst. Nagoya
Government Industrial Res. Inst. Kyushu
Fermentation Res. Inst.
Government Industrial Res. Inst. Tohoku
Res. Inst. for Polymers and Textiles
Government Industrial Res. Inst. Shikoku
Geological Survey of Japan
Government Industrial Res. Inst. Chugoku
Japan Key Technology Center
New Energy and Industrial Technology Development Organization
③
Ministry of Transportation
Council for Transport Technics
Ship Technical Res. Inst.
Port & Harbour Technical Res. Inst.
Electronics Navigation Inst.
Traffic Safety and Nuisance Res. Inst.
Maritime Safety Agency
Maritime Safety Agency Research Center
Hydrographic Department
Meteorological Agency
Meteorological Res. Inst.
Ministry of Posts & Telecommunications
Telecommunications Technology Council
Communications Res. Lab.
Japan Broadcasting Corporation (NHK)
NHK Science and Technical Res. Labs.
Telecommunications Satellite Corporation of Japan
Japan Key Technology Center
Ministry of Labour
Res. Inst. of Industrial Safety
National Inst. of Industrial Health
Ministry of Construction
Geographical Survey Inst.
Public Works Res. Inst.
Building Res. Inst.
Ministry of Home Affairs
Fire Defence Agency
Fire Res. Inst.

3. Budget for Science and Technology

Japan's budget for science and technology amounted to ¥1,757 billion in fiscal 1988 an increase of 3.2% to the previous year. The Government's fiscal 1988 general account budget registered an increase of 4.8 percent.

Chart 53 Trends in Science and Technology Budgets by Item

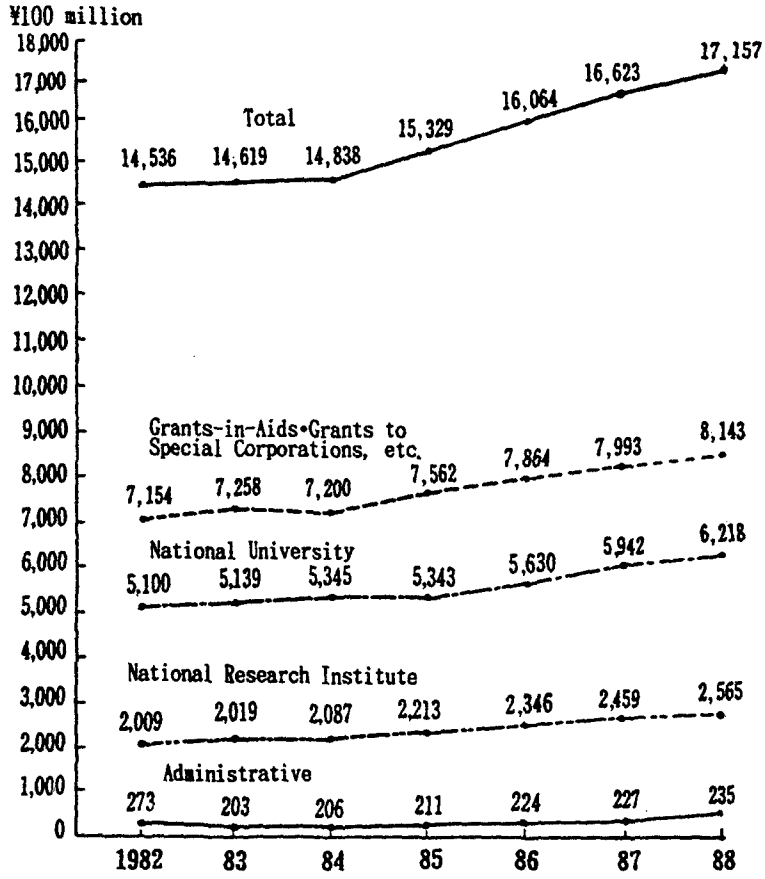


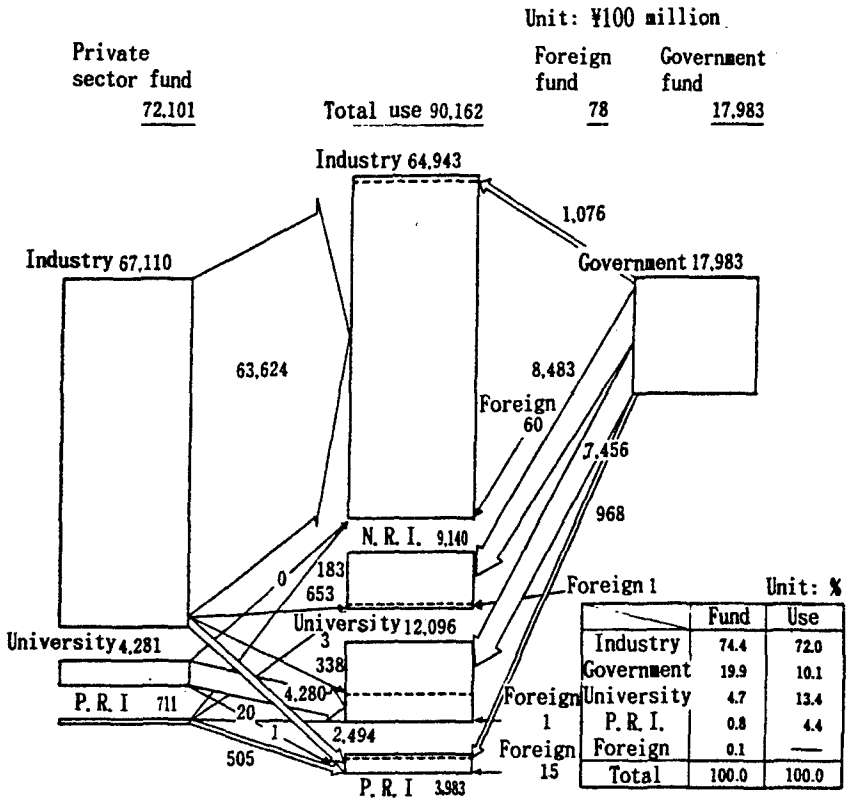
Table 3 Science and Technology Budgets of the Government

(million ¥)

FY / Agency	1989 A	1989 B	1989 (A+B)Total	1988 A	1988 B	1988 (A+B)Total
Diet	533	—	533	517	—	517
Science Council of Japan	—	867	867	—	903	903
National Police Agency	1,020	—	1,020	972	—	972
Hokkaido Development Agency	147	—	147	143	—	143
Defence Agency	—	93,068	93,068	—	82,700	82,700
Economic Planning Agency	764	—	764	716	—	716
Science & Technology Agency	189,400	277,223	466,623	170,978	269,215	440,193
Environment Agency	7,882	—	7,882	7,752	—	7,752
National Land Agency	160	—	160	105	—	105
Min. of Justice	871	—	871	849	—	849
Min. of Foreign Affairs	—	6,408	6,408	—	6,417	6,417
Min. of Finance	348	739	1,087	337	641	978
Min. of Education	68,439	785,883	854,322	63,757	749,197	812,954
Min. of Health & Welfare	36,371	12,000	48,371	32,319	11,740	44,059
Min. of Agriculture, Forestry & Fisheries	62,350	5,687	68,037	61,195	5,447	66,642
Min. of International Trade & Industry	55,799	177,850	233,649	54,652	166,574	221,226
Min. of Transportation	13,225	3,078	16,303	12,461	2,165	14,627
Min. of Posts & Telecommunications	4,341	26,523	30,864	4,169	26,113	30,282
Min. of Labour	612	3,945	4,557	601	3,107	3,708
Min. of Construction	5,376	313	5,689	5,205	254	5,459
Min. of Home Affairs	555	—	555	543	—	543
Total	448,033	1,367,583	1,815,616	417,272	1,298,473	1,715,745

Note: A: Budget for Promotion of Science & Technology and Energy R&D
B: Budget for science & technology except A

Chart 54 The Flow of R&D Funds in Japan (FY 1987)



Note: N. R. I. : National research institute
P. R. I. : Private research institute

(Reference 1)

R&D Activity in Japan (1988 preliminary figure)
"Summary of the 1989 Survey Results of Scientific and Technological Research".

1. Research and Development Expenditures

(1) Total R&D Expenditures (1988)

Category	Total amount	Natural sciences
Total R&D Expenditures (nominal)	¥10.6276 trillion	¥9.7752 trillion
- Percent increase from the preceding year	8.0%	8.4%
Total R&D Expenditures (real)	¥10.5269 trillion	¥9.7265 trillion
- Percent increase from the preceding year	5.6%	6.0%

(Note) "Real" figures are on the 1985 basis.

(2) Ratio of the 1988 R&D Expenditures to GNP

Category	Total amount	Natural sciences
- Percentage of R&D Expenditures	2.85%	2.62%
- Percentage of public expenditures	0.57%	0.48%

(Note) GNP in 1988 is 372.5 trillion yen.

(3) Breakdown of the 1988 R&D Expenditures by Funding Source

Category	Total amount	Natural sciences
Total amount	¥10.6276 trillion	¥9.7752 trillion
- Percent increase from the preceding year	8.0%	8.4%
- Percentage in total	100.0%	100.0%
Public sector	¥2.1178 trillion	¥1.8014 trillion
- Percent increase from the preceding year	0.3%	0.2%
- Percentage in total	19.9%	18.4%
Private sector	¥8.5015 trillion	¥7.9655 trillion
- Percent increase from the preceding year	10.2%	10.5%
- Percentage in total	80.0%	81.5%
Overseas sources	¥8.3 billion	¥8.2 billion
- Percent increase from the preceding year	1.0%	5.9%
- Percentage in total	0.1%	0.1%

(4) The Amount and Percentage in Total R&D Expenditures Spent by Various Organizations (1988)

Category	Total amount	Natural sciences
Total amount	¥10.6276 trillion	¥9.7752 trillion
- Percent increase from the preceding year	8.0%	8.4%
- Percentage in total	100.0%	100.0%
Industry	¥7.2193 trillion	¥7.2193 trillion
- Percent increase from the preceding year	11.2%	11.2%
- Percentage in total	67.9%	73.9%
Research institutes	¥1.3942 trillion	¥1.3163 trillion
- Percent increase from the preceding year	0.7%	0.3%
- Percentage in total	13.1%	13.5%
Universities	¥2.0141 trillion	¥1.2396 trillion
- Percent increase from the preceding year	2.9%	2.5%
- Percentage in total	19.0%	12.7%

(5) Proportion of R&D Expenditures by Character of Research

Category	Basic research	Applied research	Developmental research
Total	13.3%	24.3%	62.4%
- Industry	6.6%	21.7%	71.7%
- Research institutes	14.9%	25.4%	59.7%
- Universities	52.8%	38.5%	8.7%

2. Number of Researchers (as of April 1, 1989)

Category	Total number	Natural sciences
Total number	535 thousand	462 thousand
- Percent increase from the preceding year	4.2%	4.5%
- Percentage in total	100.0%	100.0%
Industry	294 thousand	294 thousand
- Percent increase from the preceding year	5.3%	5.3%
- Percentage in total	55.0%	63.7%
Research institutes	40 thousand	36 thousand
- Percent increase from the preceding year	4.0%	3.6%
- Percentage in total	7.5%	7.7%
Universities	201 thousand	132 thousand
- Percent increase from the preceding year	2.7%	2.8%
- Percentage in total	37.5%	28.5%

3. Technological Balance of Payment (1988)

Amount Received (1)	246.3 billion
(New contract)	(47.4 billion)
Amount Paid (2)	312.2 billion
(New contract)	(54.6 billion)
Balance of Payments (1)/(2)	0.79
(New contract)	(0.87)

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